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Society
FOR THE
Promotion of Engineering Education

PROCEEDINGS
OF THE
TWELFTH ANNUAL MEETING

HELD IN
ST. LOUIS, MO., SEPTEMBER 1-3, 1904

Volume XII.

EDITED BY
C. FRANK ALLEN FRED W. MCNAIR MILO S. KETCHUM
Committee

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1904-1905.

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LIST OF MEMBERS.

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ABBOTT, FREDERICK B..... Emporia, Kansas.	Professor of Manual Training, Kansas State Normal.....	1904
ADAMS, CHARLES L..... 23 Burr St., Jamaica Plain, Mass.	Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology.....	1904
ADAMS, COMFORT A., JR... Cambridge, Mass	Assistant Professor of Electrical En- gineering, Harvard University.....	1894
ALDERSON, VICTOR C..... Golden, Colo.	President of Colorado School of Mines.	1900
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ALLEN, C. FRANK..... Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technol- ogy	1893
ALLEN, CHARLES M..... 8 Dean St., Worcester, Mass.	Assistant Professor of Experimental Engineering, Worcester Polytechnic Institute	1903
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AYERS, BROWN..... Knoxville, Tenn.	President of the University of Tennessee	1898
BAKER, IBA O..... Champaign, Ill.	Professor of Civil Engineering, University of Illinois.....	1893
BAKER, JOHN S..... Bozeman, Mont.	Professor of Civil Engineering, Montana Agricultural College.....	1904
BARNES, FRED A..... 515 N. Aurora St., Ithaca, N. Y.	Instructor in Civil Engineering, Cornell University.	1904
BARNEY, SAMUEL E., JR... New Haven, Conn.	Assistant Professor of Civil Engineer- ing, Yale University.....	1894
BARR, JOHN H..... Syracuse, N. Y.	Smith Premier Typewriter Company..	1902
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BARBOWS, HAROLD K..... Boston, Mass.	Engineer U. S. Geological Survey....	1902
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BASS, FREDERIC H..... Minneapolis, Minn.	Assistant Professor of Civil Engineer- ing, University of Minnesota.....	1904
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BENJAMIN, CHARLES H.... Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science.....	1893
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BEYER, T. RAYMOND..... 119 Maplewood Ave., Germantown, Pa.	Civil Engineer.....	1895
BISSELL, GEORGE W..... Ames, Iowa.	Professor of Mechanical Engineering, Iowa State College.....	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
BIXBY, WILLIAM H..... 246 Belvidere Ave., Detroit, Mich.	Lieut. Col. Corps of Engineers, U. S. Army, U. S. Engineer Office.....	1893
BLANCHARD, ARTHUR H.... Brown University, Providence, R. I.	Assistant Professor of Civil Engineer- ing, Brown University.....	1902
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BRAY, CHARLES D..... Tufts College, Mass.	Professor of Civil and Mechanical En- gineering, Tufts College.....	1894
BRECKENRIDGE, LESTER P.. Urbana, Ill.	Professor of Mechanical Engineering, University of Illinois.....	1893
BREED, CHARLES B..... Boston, Mass.	Instructor in Civil Engineering, Mas- sachusetts Institute of Technology..	1904
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BROOKE, WILLIAM E..... Minneapolis, Minn.	Instructor in Engineering Mathe- matics, University of Minnesota....	1902
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CARPENTER, LOUIS G..... Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College, State Engineer of Colorado..	1895
CARPENTER, ROLLA C..... Ithaca, N. Y.	Professor of Experimental Engineering, Cornell University.....	1893
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CHASE, CHARLES H..... 37 Lincoln St., Stoneham, Mass.	Assistant Professor of Steam Engineering, Tufts College.....	1900
CHATBURN, GEORGE R..... Lincoln, Neb.	Assistant Professor of Civil Engineering, University of Nebraska.....	1899
CHRISTY, SAMUEL B..... Berkeley, Cal.	Professor of Mining and Metallurgy, University of California.....	1893
COLBURN, GEORGE L..... New Bedford, Mass.	Principal of the Mechanical Department, New Bedford Textile School...	1901
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CONSTANT, FRANK H..... Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota.....	1896
COOLEY, MORTIMER E..... Ann Arbor, Mich.	Professor of Mechanical Engineering and Dean of Department of Engineering, University of Michigan.....	1893
CORTHELL, ELMER L..... 1 Nassau St., New York, N. Y.	Civil Engineer.....	1895
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CRENSHAW, BOLLING H.... Auburn, Ala.	Associate Professor of Mathematics, Alabama Polytechnic Institute.....	1894
CRUIKSHANK, BARTON..... Syracuse, N. Y.	With Subway Process Co.....	1899
DATES, HENRY B..... Boulder, Colo.	Professor of Electrical Engineering and Dean of School of Applied Science, University of Colorado.....	1904
DAVIS, ELLERY W..... Lincoln, Neb.	Dean of College of Literature, Science and the Arts, University of Nebraska.	1902
DEAN, ARTHUR D..... Springfield, Mass.	First Assistant, Mechanic Arts High School	1901
DEFOE, LUTHER M..... Columbia, Mo.	Professor of Mechanics, University of Missouri	1904
DENISON, CHARLES S..... Ann Arbor, Mich.	Professor of Stereotomy, Mechanism and Drawing, University of Michigan.	1893
DENTON, JAMES E..... Hoboken, N. J.	Professor of Mechanical Engineering and Shopwork, Stevens Institute of Technology	1893
DENTON, FREDERICK W.... Houghton, Mich.	Superintendent Baltic and Trimoun- tain Mines.....	1894
DERLETH, CHARLES, JR.... Berkeley, Cal.	Professor of Structural Engineering, University of California.....	1904
DIEMER, HUGO..... Chase & Virginia Aves., Cincinnati, Ohio.	Consulting Mechanical Engineer.....	1902
DOHERTY, HENRY L..... 40 Wall St., New York, N. Y.	Consulting Engineer.....	1904
DRANE, WALTER H..... University, Miss.	Professor of Civil Engineering, University of Mississippi.....	1893
DU BOIS, A. JAY..... New Haven, Conn.	Professor of Civil Engineering, Yale University.....	1894
DUDLEY, CHARLES B..... Altoona, Pa.	Chemist, Pennsylvania Railroad Com- pany.	1894
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DUNCAN, LOUIS..... 56 Pine St., New York, N. Y.	Consulting Electrical Engineer.....	1904

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DURAND, WILLIAM F..... Ithaca, N. Y.	Professor of Marine Engineering, Cornell University.....	1899
EDDY, HENRY T..... Minneapolis, Minn.	Professor of Engineering and Mechan- ics, University of Minnesota.....	1893
EDDY, HORACE T..... Cincinnati, Ohio.	Professor of Electrical Engineering, University of Cincinnati.....	1903
EDMANDS, SAMUEL S..... Brooklyn, N. Y.	Instructor in Applied Electricity, Pratt Institute	1903
EMCH, ARNOLD..... Boulder, Colo.	Professor of Graphics and Mathe- matics, University of Colorado.....	1904
EMORY, FREDERICK L..... Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia Uni- versity	1894
ENGLER, EDMUND A..... Worcester, Mass.	President, Worcester Polytechnic In- stitute	1897
ESTERLINE, J. WALTER..... 401 State St., West Lafayette, Ind.	Assistant Professor of Electrical En- gineering, Purdue University.....	1903
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FAIG, JOHN T..... Lexington, Ky.	Professor of Machine Design, State College of Kentucky.....	1899
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FERMIER, EMILE J..... West Lafayette, Ind.	Instructor in Applied Mechanics, Purdue University.....	1903
FERNALD, ROBERT H..... St. Louis, Mo.	Professor of Mechanical Engineering, Washington University.....	1899
FISHER, JAMES, JR..... Houghton, Mich.	Professor of Mathematics and Phys- ics, Michigan College of Mines.....	1899
FLATHER, JOHN J..... Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota.....	1893
FLETCHER, ROBERT..... Hanover, N. H.	Professor of Civil Engineering, Direc- tor of Thayer School of Civil Engi- neering, Dartmouth College.....	1894
FLINT, WALTER..... Port Deposit, Md.	Supervising Engineer, The Jacob Tome Institute.....	1898

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FORD, ARTHUR H..... Atlanta, Ga.	Professor of Electrical Engineering, Georgia School of Technology.....	1903
FOSS, FRED E..... State College, Pa.	Professor of Civil Engineering, Pennsylvania State College.....	1893
FOWLER, CHARLES E..... 95 Gesler Way, Seattle, Wash.	President of Puget Sound Bridge and Dredging Co.....	1903
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FRANKFORTER, GEORGE B.... Minneapolis, Minn.	Professor of Chemistry, University of Minnesota.	1897
FRANKLIN, WILLIAM S..... Bethlehem, Pa.	Professor of Physics, Lehigh Univer- sity.	1900
FREEDMAN, WILLIAM H.... 116 Main St., Burlington, Vt.	Professor of Electrical Engineering, University of Vermont.....	1902
FREEMAN, CLARENCE E..... Chicago, Ill.	Director of Electrical Engineering De- partment, Armour Institute of Tech- nology	1904
FRENCH, ARTHUR W..... Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute.....	1900
FRENCH, THOMAS E..... Columbus, Ohio.	Associate Professor of Architecture and Drawing, Ohio State University.	1899
FRINK, FRED G..... Urbana, Ill.	Assistant Professor of Civil Engineer- ing, University of Illinois.....	1902
FULLAN, M. THOMAS J.... Auburn, Ala.	Assistant in Mechanical Engineering, Alabama Polytechnic Institute.....	1897
FULLER, ALMON H..... University Station, Seattle, Wash.	Professor of Civil Engineering, University of Washington.....	1901
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GANZ, ALBERT F..... Hoboken, N. J.	Professor of Electrical Engineering, Stevens Institute.....	1903
GIESECKE, F. E..... College Station, Tex.	Professor of Drawing, Texas Agricul- tural and Mechanical College.....	1893

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GLADSON, WILLIAM N..... Fayetteville, Ark.	Professor of Electrical Engineering, University of Arkansas.....	1903
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GOODENOUGH, GEORGE A.... Urbana, Ill.	Assistant Professor of Mechanical Engineering, University of Illinois....	1900
GOSS, WILLIAM F. M..... Lafayette, Ind.	Professor of Experimental Engineering and Dean of Schools of Engineering, Purdue University.....	1893
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HALSTED, GEORGE B..... Annapolis, Md.	Professor of Mathematics, St. John's College.....	1899
HAMERSCHLAG, ARTHUR A.. Pittsburg, Pa.	Director, Carnegie Technical Schools.	1903
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HARRIS, ELMO G..... Rolla, Mo.	Professor of Civil Engineering, School of Mines and Metallurgy, University of Missouri.....	1894
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HATT, WILLIAM K..... Lafayette, Ind.	Professor of Applied Mechanics, Pur- due University.....	1895
HAVILAND, EDWIN, JR..... Potsdam, N. Y.	Professor of Mathematics and Civil Engineering, Clarkson School of Technology	1902
HAWES, JOSEPH H..... Durham, N. H.	Associate Professor of Drawing, New Hampshire College of Agricul- ture and the Mechanic Arts.....	1900
HAYNES, ARTHUR E..... Minneapolis, Minn.	Professor of Engineering Mathematics, University of Minnesota.....	1895
HAYWARD, HARRISON W.... Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Tech- nology	1904
HAZEN, JOHN V..... Hanover, N. H.	Professor of Civil Engineering, Dartmouth College.....	1896
HEDRICK, IRA G..... 608 New Nelson Bldg., Kansas City, Mo.	Consulting Engineer.....	1903
HELLER, ALBERT H..... 1249 Niel Ave., Columbus, Ohio.	Professor of Civil Engineering, Ohio State University.....	1903
HERGET, ALBERT M..... 311 Convention St., Baton Rouge, La.	Professor of Drawing and Mechanic Arts, Louisiana State University...	1903
HIBBARD, H. WADE..... Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
HILL, JOHN E..... Providence, R. I.	Professor of Civil Engineering, Brown University.....	1894
HITCHCOCK, EMBURY A.... Columbus, Ohio.	Professor of Experimental Engineer- ing, Ohio State University.....	1899

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HOAG, WILLIAM R. Minneapolis, Minn.	Professor of Civil Engineering, University of Minnesota.....	1893
HOFMAN, HEINRICH O. Boston, Mass.	Professor of Metallurgy, Massachu- setts Institute of Technology.....	1894
HOLDEN, CHARLES A. Hanover, N. H.	Assistant Professor of Civil Engineer- ing and Mathematics, Thayer School of Civil Engineering, Dartmouth Col- lege	1901
HOLLIS, IRA N. Cambridge, Mass.	Professor of Engineering, Harvard University.....	1894
HOOD, OZNI P. Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
HORTON, GEORGE F. Throop and 105th Sts. Chicago, Ill.	Vice-President of Chicago Bridge and Iron Co.....	1903
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HOTCHKISS, O. W. 401 LaSalle St., Chicago, Ill.	Consulting Engineer.....	1904
HOWE, CHARLES S. Cleveland, Ohio.	President of Case School of Applied Science	1902
HOWE, MALVERD A. Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute.....	1894
HUME, ALFRED. University, Miss.	Professor of Mathematics, University of Mississippi.....	1894
HUMPHREYS, ALEXANDER C. Hoboken, N. J.	President of Stevens Institute of Technology	1903
HUMPHREYS, DAVID C. Lexington, Va.	Dean of the School of Engineering and Professor of Civil Engineering, Washington and Lee University.....	1893
HUNTER, JOHN A. Boulder, Colo.	Assistant Professor of Mechanical Engineering, University of Colorado	1904
HUTTON, FREDERICK R. New York, N. Y.	Professor of Mechanical Engineering, Columbia University.....	1894
HYDE, A. LINCOLN. University Club, Columbia, Mo.	Assistant Professor of Bridge Engi- neering, University of Missouri....	1904

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
IVES, HOWARD C..... Philadelphia, Pa.	Assistant Professor of Civil Engineering, University of Pennsylvania.....	1901
JACKSON, DUGALD C..... Madison, Wis.	Professor of Electrical Engineering, University of Wisconsin.....	1893
JACKSON, JOHN P..... State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College.....	1894
JACOBUS, D. S..... Hoboken, N. J.	Professor of Experimental Mechanics and Engineering Physics, Stevens Institute of Technology.....	1893
JACOBY, HENRY S..... Ithaca, N. Y.	Professor of Bridge Engineering, Cornell University.....	1894
JAMES, WALTER H..... Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1904
JAMESON, JOSEPH M..... Brooklyn, N. Y.	Instructor in Physics, Pratt Institute	1903
JENSON, JOSEPH..... Logan, Utah.	Professor of Mechanical Engineering, State Agricultural College of Utah..	1903
JETT, CARTER C..... 3200 West Ave., Newport News, Va.	Draughtsman Newport News Shipbuilding and Dry-dock Co.....	1902
JOHNSON, LEWIS J..... Cambridge, Mass.	Assistant Professor of Civil Engineering, Lawrence Scientific School, Harvard University.....	1893
JONES, BASSETT, JR..... 1 Madison Ave., New York, N. Y.	Consulting Engineer.....	1904
JONES, CLEMENT R..... Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University.....	1895
JONES, FORREST R..... Ithaca, N. Y.	Professor of Machine Design, Sibley College, Cornell University.....	1893
JONES, FREDERICK S..... Minneapolis, Minn.	Professor of Physics and Dean of College of Engineering, University of Minnesota	1903
KAUP, WILLIAM J..... Brooklyn, N. Y.	Instructor in Machine Construction, Pratt Institute.....	1903
KAVANAUGH, WILLIAM H.. Minneapolis, Minn.	Assistant Professor of Mechanical Engineering, in charge of Experimental Engineering, University of Minnesota	1902

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
KAY, EDGAR B..... University, Ala.	Professor of Civil Engineering, University of Alabama.....	1898
KENERSON, WILLIAM H.... 11 Hudson St., Providence, R. I.	Assistant Professor of Mechanical Engineering, Brown University.....	1903
KENNEDY, FRANK LOWELL.. 5 Mercer Circle, Cambridge, Mass.	Assistant Professor of Drawing and Machine Design, Lawrence Scientific School, Harvard University.....	1904
KENT, JAMES M..... Kansas City, Mo.	Professor in Manual Training High School of Kansas City.....	1903
KENT, WILLIAM..... Syracuse, N. Y.	Dean of the College of Applied Science, Syracuse University.....	1894
KENYON, ALFRED M..... 103 Waldron St., West Lafayette, Ind.	Professor of Mathematics, Purdue University	1903
KERR, CHARLES V..... 3321 Armour Ave., Chicago, Ill.	Professor of Mechanical Engineering, Armour Institute.....	1902
KETCHUM, MILO S..... Boulder, Colorado.	Professor of Civil Engineering, University of Colorado.....	1903
KINEALY, JOHN H..... St. Louis, Mo.	Consulting Mechanical Engineer.....	1893
KING, ROY S..... Minneapolis, Minn.	Instructor in Mechanical Laboratory, University of Minnesota.....	1904
KINGSBURY, ALBERT..... East Pittsburg, Pa.	Mechanical Engineer, with Westinghouse Electric and Manufacturing Co.	1893
KINSLEY, CARL..... Quadrangle Club, Chicago, Ill.	Assistant Professor of Physics, University of Chicago.....	1903
KNOCH, JULIUS J..... Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas.....	1898
KOCH, EVERETT H., JR.... 2363 N. 13th St., Philadelphia, Pa.	Master in Pure and Applied Mathematics, Mackenzie School, Dobbs Ferry, N. Y.....	1904
KYSER, HENRY H..... Clemson College, S. C.	Assistant Professor of Electrical Engineering, Clemson Agricultural College	1897

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
LADD, GEORGE E..... Rolla, Mo.	Director and Professor of Geology and Mining, School of Mines and Metallurgy	1901
LAMBERT, PRESTON A..... South Bethlehem, Pa.	Assistant Professor of Mathematics, Lehigh University.....	1897
LANDRETH, OLIN H..... Schenectady, N. Y.	Professor of Civil Engineering, Union College	1893
LANE, HENRY M..... Rose Building, Cleveland, Ohio.	Editor of the Foundry.....	1900
LANGSDORF, ALEXANDER S.. St. Louis, Mo.	Professor of Electrical Engineering, Washington University.....	1903
LANZA, GAETANO. Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology.....	1893
LAWRENCE, JAMES W..... Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College.....	1898
LINVILLE, CLARENCE P..... Box 362, State College, Pa.	Instructor in Metallurgy, Pennsylvania State College.....	1904
LOVE, ANDREW C..... Houston, Tex., Care of S. P. Ry.		1900
LUDY, LLEWELLYN V..... 229 University St., West Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University.....	1903
LUND, ROBERT L..... Little Rock, Ark.	Consulting Engineer.....	1902
MCCAUSTLAND, ELMER J... Ithaca, N. Y.	Assistant Professor of Mining and Surveying, Cornell University.....	1902
MCCOLL, JAY R..... Lafayette, Ind.	Associate Professor in Steam Engineering, Purdue University.....	1894
MCKIBBEN, FRANK P..... Boston, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1904
McNAIR, FRED W..... Houghton, Mich.	President, Michigan College of Mines.	1897

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MACK, JOHN G. D..... 222 Jefferson St., Madison, Wis.	Professor of Machine Design, College of Engineering, University of Wis- consin.....	1901
MACOMBER, GEORGE S..... Ithaca, N. Y.	Instructor in Electrical Engineering, Sibley College, Cornell University..	1904
MACOMBER, IRWIN J..... 422 Thirty-fourth St., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology....	1902
MAGOWAN, CHARLES S..... Iowa City, Iowa.	Professor of Municipal and Sanitary Engineering, State University of Iowa	1896
MAGRUDER, WILLIAM T.... Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University.....	1893
MAITLAND, ALEXANDER, JR. 1109 McGee St., Kansas City, Mo.	President of Kansas City Bridge Co..	1903
MANN, JOHN L..... Hanover, N. H.	Associate Professor of Civil Engineer- ing and Mechanical Drafting, Thayer School of Civil Engineering.....	1902
MARBURG, EDGAR..... Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania.....	1894
MARSTON, ANSON..... Ames, Iowa.	Professor of Civil Engineering, Iowa State College.....	1894
MARVIN, FRANK O..... Lawrence, Kan.	Dean of the School of Engineering, Professor of Civil Engineering, University of Kansas.....	1893
MARX, CHARLES D..... Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University..	1893
MATHER, THOMAS W..... Miami, Fla.		1894
MATHEWS, HUBERT B..... Brookings, S. Dak.	Professor of Physics and Electrical Engineering, South Dakota Agri- cultural College.....	1896
MATTHEWS, CHARLES P.... Lafayette, Ind.	Professor of Electrical Engineering, Purdue University.....	1898
MAUREE, EDWARD R..... Madison, Wis.	Professor of Mechanics, University of Wisconsin.....	1897

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
MEAD, ELWOOD..... Washington, D. C.	Professor of the Institutions and Practice of Irrigation, University of California; Expert in charge of Irrigation Investigations of the U. S. Department of Agriculture.....	1901
MEEKER, WARREN H..... Ames, Iowa.	Associate Professor of Mechanical Engineering, Iowa State College.....	1903
MEES, CARL L..... Terre Haute, Ind.	President, Rose Polytechnic Institute	1894
MENDENHALL, THOMAS C... Worcester, Mass.		1895
MERRIMAN, MANSFIELD..... South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1893
MIGGETT, WILLIAM L..... 331 Jefferson St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan.....	1902
MILLAR, ADAM V..... 404 W. Mifflin St., Madison, Wis.	Instructor in Mechanical Drawing and Descriptive Geometry, University of Wisconsin	1904
MONIN, LOUIS C..... Chicago, Ill.	Dean of Culture Studies and Professor of Economics and Philosophy, Armour Institute of Technology....	1904
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MORE, CHARLES C..... Port Townsend, Wash.	U. S. Engineer's Office.....	1901
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MOYER, JAMES A..... Cambridge, Mass.	Instructor in Descriptive Geometry, Lawrence Scientific School, Harvard University	1904
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NAGLE, JAMES C..... College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas.....	1897
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RAYMOND, HOWARD M..... Chicago, Ill.	Dean of Engineering Studies and Pro- fessor of Experimental Physics, Armour Institute of Technology....	1904
RAYMOND, WILLIAM G..... Iowa City, Iowa.	Professor of Civil Engineering and Head of Departments of Engineering, University of Iowa.....	1893

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REBER, LOUIS E..... State College, Pa.	Dean of School of Engineering, Professor of Mechanical Engineering, Pennsylvania State College.....	1893
REYNOLDS, HERMAN W..... Agricultural College, Mich.	Assistant Professor of Mechanical Engineering, Michigan Agricultural College	1903
RICHARDS, CHARLES R..... Lincoln, Neb.	Professor of Mechanical Engineering and Director of the School of Mechanic Arts, University of Nebraska.	1895
RICHARDS, CHAS. RUSSELL. New York, N. Y.	Director of Manual Training, Teachers College, Columbia University...	1904
RICHARDS, ROBERT H..... Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology.....	1895
RICHARDSON, JAMES P..... 3918 Wyandotte St., Kansas City, Mo.	Prosser School.....	1903
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RICKER, N. CLIFFORD..... Urbana, Ill.	Dean of College of Engineering, University of Illinois.....	1894
RIGGS, WALTER M..... Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Department of Mechanical and Electrical Engineering, Clemson (A & M) College, South Carolina.....	1897
ROBBINS, ARTHUR G..... Boston, Mass.	Assistant Professor of Highway Engineering, Massachusetts Institute of Technology	1894
ROBERTS, WILLIAM J..... Pullman, Wash.	Associate Professor of Mathematics and Civil Engineering, Washington Agricultural College and School of Science	1903
ROBINSON, EDWARD..... Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont.....	1899
ROBINSON, FREDERIC H..... Newark, Del.	Professor of Civil Engineering, Delaware College.....	1894
ROBINSON, STILLMAN W.... Columbus, Ohio.	Mechanical Engineer and Expert, 1353 Highland St.....	1893

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RODHOUSE, THOMAS J..... Columbia, Mo.	Instructor of Descriptive Geometry and Mechanical Drawing, University of Missouri	1904
RONDINELLA, LINO F..... 728 Stephen Girard Bldg., Philadelphia, Pa.	Professor of Constructive Drawing, Central Manual Training School of Philadelphia	1903
ROSEBRUGH, THOMAS R.... Toronto, Ontario.	Associate Professor of Electrical Engi- neering, School of Practical Science.	1896
ROWE, GEORGE H..... Stanford University. Cal.	Professor of Electrical Engineering, Leland Stanford Junior University.	1903
ROWLAND, ARTHUR J..... 4510 Osage Ave., Philadelphia, Pa.	Professor of Electrical Engineering, Drexel Institute.....	1903
RUSSELL, WALTER B..... Brooklyn N. Y.	Assistant Instructor in Steam and Me- chanical Laboratory, Pratt Institute.	1903
RYAN, HARRIS J..... 114 Cascadilla Place, Ithaca, N. Y.	Professor of Electrical Engineering, Sibley College, Cornell University..	1901
SANBORN, FRANK E..... Columbus, O.	Director, Industrial Arts Department, Secretary of the College of Engineer- ing, Ohio State University.....	1899
SCHNEIDER, HERMAN..... Cincinnati, O.	Professor of Civil Engineering, University of Cincinnati.....	1903
SCHUERMAN, WILLIAM H... Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University.....	1895
SCOTT, ARTHUR C..... Austin, Tex.	Professor of Electrical Engineering, University of Texas.....	1903
SCOTT, CHARLES F..... Pittsburg, Pa.	Consulting Engineer, Westinghouse Electric and Manufacturing Com- pany	1904
SEDGWICK, WILLIAM T.... Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology.....	1896
SEVER, GEORGE F..... New York, N. Y.	Adjunct Professor of Electrical En- gineering, Columbia University....	1903
SHELDON, SAMUEL..... Brooklyn, N. Y.	Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SHEPARDSON, GEORGE D..... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota.....	1895
SHORT, ROBERT L..... Chicago, Ill.	With D. C. Heath & Co.....	1902
SLOCUM, ROY H..... Urbana, Ill.	Instructor in Theoretical and Applied Mechanics, University of Illinois....	1903
SMITH, ALBERT W..... 1101 East Madison Ave., Cleveland, Ohio.	Professor of Metallurgy, Case School of Applied Science.....	1904
SMITH, ALTON L..... Worcester, Mass.	Assistant Professor of Drawing and Machine Design, Worcester Polytech- nic Institute.....	1902
SMITH, HAROLD B..... Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute....	1898
SMITH, HARRY E..... Brooklyn, N. Y.	Professor of Applied Mechanics, Pratt Institute	1895
SMITH, HERBERT S. S..... Princeton, N. J.	Professor of Applied Mechanics, Princeton University.....	1894
SMITH, LEONARD S..... 938 University Ave., Madison, Wis.	Assistant Professor of Topographic and Geodetic Engineering, University of Wisconsin	1903
SNOW, CHARLES H..... New York, N. Y.	Dean of School of Applied Science, New York University.....	1895
SNOW, WALTER B..... 29 Russel Ave., Watertown, Mass.	Mechanical Engineer, B. F. Sturtevant Co., Jamaica Plain, Mass.....	1899
SOLBERG, HALVOR C..... Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College..	1894
SPALDING, FREDERICK P.... Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri.....	1893
SPANGLER, HENRY W..... Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania.....	1895
SPIER, FREDERICK W..... Houghton, Mich.	Professor of Civil and Mining Engi- neering, Michigan College of Mines..	1896
SPINNEY, LOUIS B..... Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State College....	1899

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SPOFFORD, CHARLES M. Boston, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1904
SPRINGER, FRANK W., Minneapolis, Minn.	Assistant Professor of Electrical Engineering, University of Minnesota..	1896
STANWOOD, JAMES B. Cincinnati, Ohio.	Director, Technical School of Cincinnati	1894
STEWART, CLINTON B. Anchor, Ill.	Civil Engineer.....	1894
STEWART, LOUIS B. Toronto, Ontario.	Lecturer in Surveying, School of Practical Science.....	1897
STONE, WINTHROP E. 146 North Grant St., Lafayette, Indiana.	President, Purdue University.....	1904
STOUT, OSCAR V. P. Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska.....	1894
STUBBS, JOSEPH E. Reno, Nev.	President, Nevada State University..	1897
SWAIN, GEORGE F. Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology....	1893
SWIFT, WALTER..... Sheffield, England.	Secretary of Technical Department, University College.....	1902
TALBOT, ARTHUR N. Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois..	1893
TALBOT, HENRY P. Boston, Mass.	Professor of Analytical Chemistry, Massachusetts Institute of Technology	1902
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TAYLOR, WILLIAM D. 415 Wisconsin Ave., Madison, Wis.	Professor of Railway Engineering, University of Wisconsin.....	1894
THALER, JOSEPH A. Bozeman, Mont.	Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts.....	1901
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THORNBURG, CHARLES L.... South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University.....	1894
TIMMERMAN, ARTHUR H.... St. Louis, Mo.	Superintendent Wagner Electric Mfg. Co.	1894
TITSWORTH, ALFRED A..... 590 George St., New Brunswick, N. J.	Professor of Civil Engineering and Graphics. Rutgers College.....	1903
TOWLE, WILLIAM M..... Enosburg Falls, Vt.		1895
TURNEAURE, FREDERICK E.. Madison, Wis.	Dean of College of Engineering, University of Wisconsin.....	1894
TURNER, DANIEL L..... 320 Broadway, N. Y.	Assistant Engineer, Rapid Transit Railway	1898
TURNER, WILLIAM P..... Lafayette, Ind.	Assistant Professor of Practical Mechanics, Purdue University.....	1900
TURBILL, SHERMAN M..... 54 Church St., Bethlehem, Pa.	Civil Engineer.....	1903
TYLER, HARRY W..... 419 Boylston St., Boston, Mass.	Professor of Mathematics, and Secretary, Massachusetts Institute of Technology	1894
VANHISE, CHARLES R..... Madison, Wis.	President, University of Wisconsin...	1904
VAN ORNUM, JOHN L..... St. Louis, Mo.	Professor of Civil Engineering, Washington University.....	1895
VEDDER, HERMAN K..... Agricultural College, Mich.	Professor of Mathematics and Civil Engineering, Michigan State Agricultural College.....	1894
VOSSKUEHLER, JOSEPH H.. Columbus, Ohio.	Assistant Professor of Architecture and Drawing, Ohio State University.	1902
VOTEY, J. WILLIAM..... Burlington, Vt.	Professor of Civil Engineering and Dean of Engineering Department, University of Vermont.....	1902
WADDELL, J. A. L..... Kansas City, Mo.	Consulting Bridge Engineer, of Waddell and Hedrick.....	1893

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WADSWORTH, JOEL E..... 22 Marsemere Place, Yonkers, N. Y.	Assistant Chief Engineer, Operating and Engineering Department, East- ern Division, American Bridge Co...	1895
WADSWORTH, M. EDWARD... State College, Pa.	Professor of Mining and Geology, Pennsylvania State College.....	1895
WALDO, CLARENCE A..... Lafayette, Ind.	Head Professor of Mathematics, Purdue University.....	1897
WALKER, ELTON D..... State College, Pa.	Professor of Hydraulic and Sanitary Engineering, Pennsylvania State Col- lege	1895
WALLACE, JOHN F..... Washington, D. C.	Chief Engineer, Panama Canal Com- mission	1903
WEBB, HOWARD S..... Orono, Me.	Professor of Electrical Engineering, University of Maine.....	1897
WHEELER, CHARLES H..... 3446 Chestnut St., Philadelphia, Pa.	Professor of Mathematics, Drexel In- stitute	1904
WHIPPLE, GEORGE C..... 220 Broadway, New York, N. Y.	Consulting Engineer and Sanitary Expert of Hazen and Whipple.....	1896
WHITE, JAMES M..... Champaign, Ill.	Professor of Architectural Engineer- ing, University of Illinois.....	1900
WHITNEY, WILLIS R..... Schenectady, N. Y.	Non-resident Associate Professor of Theoretical Chemistry, Massachu- setts Institute of Technology, Bos- ton, Mass.; Director of Research Laboratory of the General Electric Company, Schenectady, N. Y.....	1902
WILEY, WILLIAM O..... 43 and 45 E. 19th St., New York, N. Y.	Publisher of Scientific Books, Secre- tary John Wiley and Sons.....	1904
WILLETT, JAMES R..... 434 Jackson Boulevard, Chicago, Ill.	Architect	1896
WILLIAMS, FRANK B..... Union College, Schenectady, N. Y.	Associate Professor of Engineering, Union College.....	1901

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
WILLIAMS, SYLVESTER N.... Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College.....	1893
WILLISTON, ARTHUR L..... Brooklyn, N. Y.	Director Department of Science and Technology, Pratt Institute.....	1897
WILMORE, JOHN J..... Auburn, Ala.	Professor of Mechanical Engineering, Alabama Polytechnic Institute.....	1894
WOOD, ARTHUR J..... State College, Pa.	Assistant Professor of Experimental Engineering, Pennsylvania State Col- lege	1898
WOODBIDGE, SAMUEL H.... Boston, Mass.	Associate Professor of Heating and Ventilation, Massachusetts Institute of Technology.....	1904
WOODWARD, CALVIN M..... St. Louis, Mo.	Dean of the School of Engineering and Architecture, Washington Uni- versity	1894
WOODWARD, ROBERT S..... New York, N. Y.	Professor of Mechanics and Mathe- matical Physics, Columbia Univer- sity	1893
WRENTMORE, CLARENCE G.. 933 Forest Ave., Ann Arbor, Mich.	Assistant Professor of Civil Engineer- ing, University of Michigan.....	1904
YOUNG, LEWIS E..... Golden, Colo.	Professor of Mining, Colorado School of Mines.....	1903
ZIMMERMAN, OLIVER B..... 222 Charter St., Madison, Wis.	Assistant Professor of Machine De- sign, University of Wisconsin.....	1902
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New York.—Aldrich, Barnes, Barr, Berg, J. S. Brown, Browne, Burr, R. C. Carpenter, Colburn, Colby, Corthell, Crandall, Doherty, Duncan, Durand, Edmands, Farwell, Foyé, Griffin, Haney, Harrington, Haviland, Hibbard, Hutton, Jacoby, Jameson, F. R. Jones, B. Jones, Kaup, W. Kent, Landreth, G. S. Macomber, McCaustland, Moran, Munroe, Norris, Pupin, Richards, Russell, Ryan, Sever, Sheldon, H. E. Smith, C. H. Snow, Turner, J. E. Wadsworth, Wiley, Whipple, Whitney, F. B. Williams, Williston, R. S. Woodward.

Ohio.—Benjamin, Bradford, H. W. Brown, Caldwell, Diemer, Horace T. Eddy, T. E. French, Heller, Hitchcock, C. S. Howe, Lane, Magruder, Neff, Orton, S. W. Robinson, Sanborn, Smith, Schneider, Stanwood, Vosskuehler.

Pennsylvania.—Atherton, Ayer, T. R. Beyer, Brady, Bruegel, Carhart, Dudley, Esty, Foss, Franklin, Hamerschlag, Ives, J. P. Jackson, Kingsbury, Koch, Lambert, Linville, Marburg, Merriman, J. M. Porter, Powell, Reber, Rondinella, Rowland, Scott, Spangler, Thornburg, Turrill, M. E. Wadsworth, Walker, Wheeler, Wood.

Rhode Island.—Blanchard, Brooks, Hill, Kenerson, Phetteplace, Randall.

South Carolina.—Kyser, Riggs, R. G. Thomas.

South Dakota.—Mathews, Solberg.

Tennessee.—Ayers, Barton, Carson, Schuerman.

Texas.—Brown, Giesecke, Love, Nagle, Puryear, Scott, T. U. Taylor.

Utah.—Jenson.

Vermont.—Barrows, Freedman, Towle, E. Robinson, Votey.

Virginia.—D. C. Humphreys, Jett, Randolph.

Washington.—Fowler, Fuller, More, Roberts.

West Virginia.—Emory, C. R. Jones.

Wisconsin.—Bull, Burgess, D. C. Jackson, Mack, Maurer, Millar, Phillips, Richter, L. S. Smith, W. D. Taylor, Turneure, Van Hise, Zimmerman.

Australia.—Barraclough.

Canada.—Bovey, Brydone-Jack, Galbraith, Owens, Pakenham, Porter, Rosebrugh, L. B. Stewart, Wright.

XXXIV GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

England.—Swift.

DIFFERENT INSTITUTIONS REPRESENTED:—

Colleges and Universities teaching engineering.....	96
Manual Training Schools.....	9
Correspondence Schools (3 representatives).....	1
One institution is represented by 23 members; one by 16; one by 14; one by 13; one by 11; two by 8; two by 7; five by 6; eight by 5; six by 4; eleven by 3; nineteen by 2; and thirty-eight by 1. Manual training schools by 9.	
Teachers, and, in many cases, also practitioners.....	330
Practicians not teachers.....	49
Total	379

GEOGRAPHICAL SUMMARY OF MEMBERS.

Alabama	4	Maryland	3	South Dakota	2
Arkansas	3	Massachusetts	41	Tennessee	4
California	6	Michigan	14	Texas	7
Colorado	11	Minnesota	14	Utah	1
Connecticut	2	Mississippi	2	Vermont	5
Delaware	2	Missouri	20	Virginia	3
District of Columbia.	2	Montana	3	Washington	4
Florida	2	Nebraska	6	West Virginia	2
Georgia	2	Nevada	1	Wisconsin	13
Illinois	26	New Hampshire.....	7	Australia	1
Indiana	19	New Jersey.....	7	Canada	9
Iowa	8	New York.....	52	England	1
Kansas	2	Ohio	20		
Kentucky	3	Pennsylvania	32	Total	379
Louisiana	4	Rhode Island.....	6		
Maine	3	South Carolina	3		

DECEASED MEMBERS.

NAME.	YEAR OF ELECTION.	DATE OF DEATH.	MEMOIR. Vol. Page.
VOLNEY G. BARBOUR.....	1894.....	June 4, 1901.	IX, 340
CHARLES B. BRUSH.....	1893.....	June 3, 1897.	VII, 181
ECKLEY B. COXE.....	1894.....	May 13, 1895.	VII, 182
THOMAS M. DROWN.....	1895.....	November 16, 1904	XII, 244
FRANCIS R. FAVA, JR....	1894.....	March 28, 1896.	VII, 183
ESTEVEAN A. FUERTES.....	1894.....	January 16, 1903.	XI, 372
HENRY FULTON.....	1894.....	December 6, 1901.	X, 258
HERBERT G. GEER.....	1894.....	March 7, 1900.	VIII, 371
JOHN B. JOHNSON.....	1893.....	June 23, 1902.	X, 259
RODNEY G. KIMBALL.....	1894.....	April 25, 1900.	X, 261
BURTON S. LANPHEAR.....	1897.....	October 14, 1904.	XII, 249
BENJAMIN F. LA RUE....	1899.....	Dec. 22, 1903.	XII, 243
JUSTUS M. SILLIMAN.....	1894.....	April 15, 1896.	VII, 184
JAMES H. STANWOOD.....	1894.....	May 24, 1896.	VII, 185
ROBERT H. THURSTON.....	1893.....	Oct. 25, 1903.	XII, 246
ALPHONSE N. VAN DAELL.	1897.....	March 28, 1899.	VII, 186
JOHN R. WAGNER.....	1894.....	January 21, 1899.	VII, 187
FRANCIS A. WALKER.....	1896.....	January 5, 1897.	VII, 188
NELSON O. WHITNEY.....	1893.....	March 17, 1901.	IX, 339
DE VOLSON WOOD.....	1893.....	June 27, 1897.	V, 325

PAST OFFICERS.

Special Committee for Division E (Engineering Education), World's
Engineering Congress, 1893.

IRA O. BAKER, Chairman, HENRY T. EDDY, Vice-Chairman,
WM. R. HOAG, Secretary, C. FRANK ALLEN, Secretary, *pro tem.*,
MORTIMER E. COOLEY, SAMUEL W. STRATTON,
STORM BULL.

PRESIDENTS.

DE VOLSON WOOD,* 1893-4, THOS. C. MENDENHALL, 1898-9,
GEORGE F. SWAIN, 1894-5, IRA O. BAKER, 1899-1900,
MANSFIELD MERRIMAN, 1895-6, FRANK O. MARVIN, 1900-01,
HENRY T. EDDY, 1896-7, ROBERT FLETCHER, 1901-02,
JOHN B. JOHNSON,* 1897-98, CALVIN M. WOODWARD, 1902-3,
C. FRANK ALLEN. 1903-04.

VICE-PRESIDENTS.

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893-4,
ROBERT H. THURSTON,* FRANK O. MARVIN, 1894-5,
FRANK O. MARVIN, CADY STALEY, 1895-6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896-7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897-8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898-9,
ROBERT FLETCHER, CHARLES D. MARX, 1899-1900,
THOMAS GRAY, ALBERT KINGSBURY, 1900-01,
STORM BULL, CALVIN M. WOODWARD, 1901-02,
JOHN J. FLATHER, FRED W. McNAIR, 1902-03,
CHARLES L. CRANDALL, JAMES C. NAGLE, 1903-04.

TREASURERS.

STORM BULL, 1893-5, CLARENCE A. WALDO, 1899-02,
JOHN J. FLATHER, 1895-9, ARTHUR N. TALBOT, 1902-04.

SECRETARIES.

JOHN B. JOHNSON,* 1893-5, EDGAR MARBURG, 1899-1900,
C. FRANK ALLEN, 1895-7, HENRY S. JACOBY, 1900-02,
ALBERT KINGSBURY, 1897-9, CLARENCE A. WALDO, 1902-04.

* Deceased.

MEMBERS OF PREVIOUS COUNCILS.

Terms of Office Expired in 1894.

M. E. COOLEY,	H. T. EDDY,	W. F. M. GOSS,
W. R. HOAG,	S. W. ROBINSON,	H. W. SPANGLER,
	R. H. THURSTON.*	

Terms of Office Expired in 1895.

H. T. BOVEY,	W. H. BURR,	O. H. LANDRETH,
MANSFIELD MERRIMAN,	W. G. RAYMOND,	G. F. SWAIN,
	DE VOLSON WOOD.*	

Terms of Office Expired in 1896.

I. O. BAKER,	STORM BULL,	S. B. CHRISTY,
JOHN GALBRAITH,	J. B. JOHNSON,*	F. O. MARVIN,
	C. D. MARX.	

Terms of Office Expired in 1897.

H. T. EDDY,	J. J. FLATHER,	J. P. JACKSON,
ALBERT KINGSBURY,	L. S. RANDOLPH,	S. W. ROBINSON,
	R. H. THURSTON.*	

Terms of Office Expired in 1898.

C. F. ALLEN,	C. L. MEES,	MANSFIELD MERRIMAN,
J. M. ORDWAY,	W. G. RAYMOND,	CADEY STALEY,
	R. S. WOODWARD.	

Terms of Office Expired in 1899.

ARTHUR BEARDSLEY,	ROBERT FLETCHER,	JOHN GALBRAITH,
WILLIAM KENT,	T. C. MENDENHALL,	W. H. SCHUERMAN,
	M. E. WADSWORTH.	

Terms of Office Expired in 1900.

STORM BULL,	L. G. CARPENTER,	ALBERT KINGSBURY,
F. O. MARVIN,	R. B. OWENS,	R. L. SACKETT,
	R. H. THURSTON.*	

Terms of Office Expired in 1901.

T. M. DROWN,*	M. A. HOWE,	I. N. HOLLIS,
GAETANO LANZA,	P. C. RICKETTS,	R. G. THOMAS,
	C. M. WOODWARD.	

Terms of Office Expired in 1902.

BROWN AYERS,	G. W. BISSELL,	J. J. FLATHER,
W. T. MAGRUDER,	F. W. MCNAIR,	J. M. PORTER,
	A. J. WOOD.	

Terms of Office Expired in 1903.

C. F. ALLEN,	D. C. JACKSON,	N. C. RICKER,
J. P. BROOKS,	EDGAR MARBURG,	A. L. WILLISTON,
	J. C. NAGLE.	

Terms of Office Expired in 1904.

W. F. M. GOSS,	THOMAS GRAY,	D. C. HUMPHREYS,
O. H. LANDRETH,	W. G. RAYMOND,	L. E. REBER,
	L. S. RANDOLPH.	

* Deceased.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. NAME.—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. In taking this ballot, Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary Members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

Life Members of the Society shall be those members not in arrears who have paid Fifty Dollars into the Treasury of the Society at one time.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting; or, during the period between Annual Meetings, the Secretary may at any time submit to the council the names of candidates with the names of their sponsors. An affirmative letter ballot of three-fourths of those whose vote reaches the Secretary within one month of the time of sending out the names of candidates will suffice to elect. Such elections shall be credited to the previous Annual Meeting, and dues will date from that time.

3. OFFICERS.—There shall be a President, two Vice-Presi-

dents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. COUNCIL.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the past Presidents of the Society shall be members of the Council *ex officio*.

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, elect candidates *ad interim*, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. NOMINATING COMMITTEE.—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five.

6. FEES AND DUES.—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearage shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

7. MEETINGS.—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National

Engineering Societies, or otherwise as the Council may determine.

8. PUBLICATION.—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. AMENDMENTS.—This Constitution may be amended by a two-thirds vote at any regular meeting, the amendment having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a programme for the same.

Second. The President, Secretary and Treasurer shall constitute an Executive Committee, which shall have charge of all matters relating to the business affairs of the Society not otherwise provided for.

Third. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Fourth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PROCEEDINGS.

THURSDAY, SEPTEMBER 1, 1904.

MORNING SESSION, 9:30 O'CLOCK.

The twelfth annual meeting of the Society was held in the Palace of Education, Louisiana Purchase Exposition, St. Louis, Missouri, September 1, 2, and 3, 1904.

The meeting was called to order by the President, C. Frank Allen.

The report of the Secretary was read and accepted. The report of the Treasurer was read and the President announced that the Council had referred the report to an Auditing Committee consisting of Professors Turneaure and Spalding.

The following applicants, approved by the Council, were elected members of the Society: Frederick B. Abbott, Charles L. Adams, George W. Atherton, John S. Baker, Fred A. Barnes, Samuel M. Barton, Frederick H. Bass, Charles B. Breed, J. A. Brooks, N. H. Brown, Raymond Burnham, Alfred E. Burton, Florian Cajori, Walter M. Camp, Stanley Coulter, Luther M. Defoe, Henry L. Doherty, Louis Duncan, Lyman Hall, Clarence E. Freeman, James A. Green, James P. Haney, Harrison W. Hayward, O. W. Hotchkiss, Abraham L. Hyde, Walter H. James, Bassett Jones, Jr., Frank L. Kennedy, Roy S. King, Everett H. Koch, Jr., Clarence P. Linville, Frank P. McKibben, Adam V.

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(1)

Millar, Louis C. Monin, James P. Munroe, William Pakenham, John B. Porter, Henry S. Pritchett, James H. Ransom, Howard M. Raymond, Charles R. Richards, Thomas J. Rodhouse, Charles F. Scott, Albert W. Smith, Charles M. Spofford, Winthrop E. Stone, Charles R. VanHise, Charles H. Wheeler, William O. Wiley, Samuel H. Woodbridge, Clarence G. Wrentmore.

The Secretary then read a letter from the Engineer's Club of St. Louis inviting the Society to an informal luncheon, Saturday, September 3, at 1:30 o'clock.

Professor A. N. Talbot offered the following resolution which was adopted:

“ *Resolved*, that the Society for the Promotion of Engineering Education expresses its appreciation of the invitation of the Engineer's Club of St. Louis to a luncheon, and regrets that circumstances connected with the meeting prevent acceptance, and that the Secretary be instructed to return the thanks of the Society for the courtesy extended.”

Professor Van Ornum extended to the Society an invitation to visit Washington University.

The literary exercises of the meeting were opened with the delivery of the annual address by the President, C. Frank Allen, on “ The Outlook for Engineering Education.”

Professor Flather, of the Committee on Entrance Requirements, made a verbal report of progress and on motion the committee was granted further time.

Professor Sperr read the report of the Committee on Requirements for Graduation. The discussion was participated in by Professors McNair, Sperr, Talbot, Greene, Gray, Jacoby, Waldo, and the President.

Professor McNair offered the following resolution which was adopted:

“ *Resolved*, that the Secretary be instructed to take such steps in the preparation of next year’s program as will lead to a definite discussion of this report.”

EVENING SESSION, 8:00 O’CLOCK.

The paper on “ A Practical Method of Instructing Engineering Students in the Biography and History of their Profession,” by Professor Robert Fletcher, was read by Professor Nagle in the absence of the author.

The paper on “ A Business Proposition,” by J. A. L. Waddell, was read by Professor Talbot. Both the above papers were discussed by Professors Bull, Magruder, A. M. Greene, Nagle, Talbot, Waldo, Jacoby, Spalding, Burton, and President Allen.

The Committee appointed to consider the proposition made to the Society that a concerted effort be made under the auspices of the Society to have published a history and biography of the engineering profession, made the following report which was accepted.

TO THE SOCIETY FOR THE PROMOTION OF ENGINEERING
EDUCATION:

Gentlemen:—Your committee appointed to consider the proposition made to the Society at the Niagara meeting by Mr. Waddell—that a concerted effort be made under the auspices of this Society to have published a history and biography of the engineering profession, has recently learned that Mr. Waddell is to present to the Society at this meeting a second paper advocating the plan he has proposed; and also that

another member of the Society has prepared a paper on the same subject to be presented at this time.

As your committee is anxious to have the benefit of these two papers and the discussions which will follow them, it begs leave to defer its report and formal recommendations to the Society until the time of the next meeting.

ARTHUR L. WILLISTON,
(*Chairman*).

FRIDAY, SEPTEMBER 2, 1904.

MORNING SESSION, 9:30 O'CLOCK.

The paper on "The Crowding of the Curriculum," by President Alexander C. Humphreys, was read by Professor Henry S. Jacoby and was discussed by Professors Johnson, Williams, C. M. Woodward, Jacoby, Turneaure, and President Allen.

Professor Arthur N. Talbot read his paper on "The Extension of Engineering Investigation Work by Engineering Schools." This paper was discussed by Professors Marston, Magruder, Greene and Ford.

Professor John G. D. Mack read his paper on "An Industrial Catalogue Library." The Secretary read a written discussion by Professor Forrest Jones and Professors Flather, Jacoby and Mack, Mr. Camp and President Allen participated in the oral discussion.

The paper on "The Naval Academy as A Technical School," by Professor Ira N. Hollis, was read by Professor L. J. Johnson, and was discussed by Professors

Hatt, Johnson, Jacoby, Nagle, Turneure, Williams, Waldo, Talbot, Maurer, Sperr and President Allen.

EVENING SESSION, 8:00 O'CLOCK.

The "Report of Committee on Technical Books for Libraries" was read by the chairman, Professor C. F. Burgess.

On motion the discussion and final action upon the report were deferred until the morning session.

A paper on "Field Work in Civil Engineering at Iowa State College," by Professor Anson Marston, was read by the author, and was discussed by Professors Bull, Smith, Marston, Ives, Turneure, Sperr, I. O. Baker, Johnson, Jacoby, Crandall, Magowan and the President.

A paper on "The Preparation of Engineering Text Books," by Professor Emory H. Powell, was read by Professor Spalding, the author not being present. The paper was discussed by Professors Jackson and Jacoby.

SATURDAY, SEPTEMBER 3, 1904.

MORNING SESSION, 9:30 O'CLOCK.

The question of the adoption of the proposed amendments to the constitution which had been approved by the council was taken up, and the amendments were voted on separately.

Amendment one was adopted unanimously, and reads as follows:

Amendment One.—Section two of constitution, beginning with second paragraph, amended to read "Hon-

orary Members of the Society shall be such persons as may be recommended by a *unanimous* vote of the Council after a letter ballot. In taking this ballot, the Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary members shall not have the right to vote, shall not be eligible to office and shall not be required to pay any fees or dues."

On motion, Amendment two was unanimously adopted and reads as follows:

Amendment two.—"Life members of the Society shall be those members not in arrears who have paid fifty dollars into the treasury of the Society at one time."

Amendment three was submitted and after being discussed by Professors Greene, Waldo and Jacoby, was adopted. It reads as follows:

Amendment three.—"The name of each candidate for ordinary membership shall be proposed in writing——shall be voted on by the Society at the annual meeting; or, during the period between annual meetings the Secretary may at any time submit to the Council the names of candidates with the names of their sponsors. An affirmative letter ballot of three fourths of those whose vote reaches the Secretary within one month of the time of sending out the names of candidates will suffice to elect. Such elections shall be credited to the previous annual meeting, and dues will date from that time."

On motion, Amendment four was adopted and reads as follows:

Amendment four.—Council—fourth paragraph, sec-

ond line, amended so as to read: "Proposals for membership, elect candidates ad interim, attend to all business, etc."

The following motion was read by Professor Henry S. Jacoby and was unanimously adopted:

"The Society for the Promotion of Engineering Education hereby expresses its hearty appreciation of the kindness of Howard J. Rogers, Director of Commerce, who, as the representative of the Louisiana Purchase Exposition, placed at its disposal the various facilities for holding its meetings in the Building for Education and Social Economy, and for other courtesies."

Vice-President Crandall was temporarily called to the chair and a motion was made by President Allen and adopted that the work of the Committee on Technical Books for Libraries be carried on, that Professor Charles F. Burgess be retained as chairman of the Committee, and that the other members of the Committee be appointed by the incoming President.

The Committee on Nominations, consisting of Past President Baker and Councilors Gray, Van Ornum, Johnson and Jacoby, made the following report which was unanimously adopted.

The Nominating Committee have the honor to present the following nominations:

For President: Fred W. McNair, President Michigan College of Mines, Houghton, Mich.

For Vice-Presidents: Professor Elwood Mead, University of California, Washington, D. C.; Professor Clement R. Jones, University of West Virginia, Morgantown, W. Va.

For Secretary: Professor Milo S. Ketchum, University of Colorado, Boulder, Colo.

For Treasurer: Professor Frederick P. Spalding, University of Missouri, Columbia, Mo.

For members of the Council whose terms are to expire in 1907: Professor Thomas Gray, Rose Polytechnic Institute, Terre Haute, Ind.; Professor Clarence A. Waldo, Purdue University, Lafayette, Ind.; Professor Arthur N. Talbot, University of Illinois, Urbana, Ill.; Professor James C. Nagle, Agricultural and Mechanical College of Texas, College Station, Tex.; Professor William G. Raymond, State University of Iowa, Iowa City, Ia.; Professor Louis E. Reber, Pennsylvania State College, State College, Pa.; Professor Robert S. Woodward, Columbia University, New York, N. Y. *I. O. Baker, Chairman; Thos. Gray, J. L. Van Ornum, L. J. Johnson, H. S. Jacoby.*

The Committee on Statistics of Engineering Education made a report of progress, and on motion was granted further time.

The Committee on Industrial Education made a report of progress, and on motion was granted further time.

A paper on "The Work of the Dean of the Faculty of the Massachusetts Institute of Technology" was read by the author, Dean Alfred E. Burton. The paper was discussed by Professors C. M. Woodward, Burton, Jacoby, McNair, Magruder and Williams.

Professor Edward H. Maurer read his paper on "Absolute and Gravitational Dynamic Units," and the paper was discussed by Professors Talbot, Woodward, Jacoby, Groat, Magruder and Maurer.

Two papers on " Teaching Calculus to Engineering Students " were read. One prepared by Professor A. H. Kenyon was read by Professor Waldo; and the other by Professor B. F. Groat was read by the author. The papers were discussed by Professors Groat, Johnson, Talbot and Waldo.

The committee appointed to audit the Treasurer's books reported that the books were correct and the Treasurer's report was formally received.

Professor C. M. Woodward escorted the President-elect, President Fred W. McNair, of the Michigan College of Mines, to the chair. After a brief and appropriate address, President McNair pronounced the meeting adjourned.

The following members registered and were present at the meeting: C. Frank Allen, C. A. Adams, Ira O. Baker, N. H. Brown, Storm Bull, C. F. Burgess, Alfred E. Burton, Charles L. Crandall, Walter M. Camp, James Fisher, A. H. Ford, Thos. E. French, J. J. Flather, A. M. Greene, Jr., B. F. Groat, Thos. Gray, W. K. Hatt, W. R. Hoag, A. L. Hyde, H. C. Ives, H. S. Jacoby, L. J. Johnson, J. P. Jackson, C. R. Jones, M. S. Ketchum, Carl Kingsley, A. S. Lamsdorf, H. M. Lane, F. W. McNair, W. T. Magruder, C. S. Magowan, E. R. Maurer, A. Marston, J. G. D. Mack, J. C. Nagle, Ed. Orton, J. D. Phillips, J. P. Richardson, L. E. Reber, G. D. Shepardson, F. P. Spalding, L. S. Smith, R. H. Slocum, F. W. Sperr, C. B. Stewart, A. N. Talbot, F. E. Turneure, J. L. Van Ornum, H. K. Vedder, C. A. Waldo, S. N. Williams, C. M. Woodward.

REPORT OF THE SECRETARY.

The membership of the Society at the beginning of the last meeting was 271. Sixty-three candidates were elected all of whom qualified but one. Several have fallen out during the year, leaving a membership of 325.

During the year at various intervals and in various ways the claims of the Society upon their time and attention have been presented to technical educators and scientific practitioners. The result has been that at this meeting the candidates for membership include the presiding and executive officers of a number of our largest technical colleges, whose names together with the large list of distinguished professors in our ranks secure for this Society, as never before, paramount influence in its chosen field.

The finances have been well guarded; the working capital has been restored and this constitutes an important element in the economical administration of its business affairs and which at one time was in danger of gradual diminution and extinction.

During the year the cause of technical education has suffered irreparable loss in the death of Robert H. Thurston, Dean of Sibley College of Cornell University. Also the death of the well-known writer Benjamin F. LaRue of the International Correspondence School has been reported.

Respectfully submitted,

CLARENCE A. WALDO, *Secretary*.

REPORT OF THE TREASURER.

The Treasurer would respectfully report as follows:

The total receipts during the year 1903-4 as given in the statement herewith, were \$1,129.64, of which \$966 were for membership dues. There is at present a balance of \$552.34, a gain of \$215.06 over that of July 1, 1903.

A condensed statement of receipts and expenditures for the year is here given.

RECEIPTS.

Cash from report of July 1, 1903.....	\$ 337.28
Sale of Proceedings, 98 copies.....	107.80

Sale of reprints to authors.....	55.84
Past dues collected.....	75.00
Current and future dues.....	891.00
Total	<u>\$1,466.92</u>

EXPENDITURES.

Expenses of Niagara Falls meeting.....\$	91.33
Printing Vol. XI. of Proceedings, etc.....	532.39
Express and other expense.....	79.69
Reprints of papers for authors.....	45.34
Secretary's supplies and expense.....	53.61
Secretary's honorarium	50.00
Treasurer's supplies and expense.....	37.22
Committee on Technical Books for Libraries.....	25.00
Balance, cash on hand	<u>552.34</u>
Total	<u>\$1,466.92</u>

Respectfully submitted,

ARTHUR N. TALBOT, *Treasurer.*

We have examined the vouchers and accounts of the Treasurer and found the same to be correct and in accordance with the above statement.

F. P. SPALDING,
F. E. TURNEAURE,
Auditing Committee.

ADDRESS BY THE PRESIDENT.

BY PROFESSOR C. FRANK ALLEN,

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Technology.

THE OUTLOOK FOR ENGINEERING EDUCATION.

Eleven years ago this summer the Society had its birth. In the Congress of Engineering at Chicago in 1893, the success of the Section devoted to Education was so great as to suggest a real demand for a permanent organization, which was secured by the foundation of this Society. From the list of members which forms a part of the volume of Proceedings published after the meeting of 1894, it appears that the membership in 1893 was 70, composed only of those who had been at Chicago, and that in 1894, the first year after there had been a general opportunity for joining the Society, it had increased to 156; there has been a steady growth from the beginning; at the close of the meeting in 1903 the membership was 326, and by the end of the present meeting the number will have reached about 375. Inasmuch as the membership had no opportunity to come to a bearing until 1894, the percentage of increase from 1893 to 1903 is unfairly large, but in the nine years from 1894 to 1903 the increase in membership is 110 per cent, and for the ten years from 1894 to 1904 the percentage will be about 140 per cent. The increase during the incumbency of our present active Secretary will be not far from 40 per cent. In the

American Society of Civil Engineers, the increase during the ten years from 1893 to 1903 is 69 per cent; the American Society of Mechanical Engineers, 61 per cent; the American Institute of Mining Engineers, 50 per cent; the American Institute of Electrical Engineers, 233 per cent; while the average for these four national societies of engineering is 77 per cent. The comparison, very favorable, on the whole, to our Society, is not only an indication of a growing interest among engineering educators, but also an assurance as to the real value and vitality of this organization.

From another standpoint, some measure of the need for such a society may be formed by considering the importance of engineering education as indicated either by the numbers of students or the numbers of graduates in engineering courses, or shall we say, by the demand for engineering education. It would be difficult or impossible to secure precise data as to the total number of students in this country who are enrolled in engineering colleges or are taking engineering courses. Some measure of the demand may be found from the proportional increase in numbers in a few typical engineering colleges somewhat separated geographically. The Massachusetts Institute of Technology shows an increase in the total number of students from 1,060 in 1893 to 1,608 in 1903, or 51 per cent; Cornell University (in engineering courses including architecture) from 762 to 1,196, or 52 per cent; the University of Wisconsin from 174 to 582, or 234 per cent; Purdue University from 317 to 950, or 200 per cent, an average for the four of 87 per cent. Without doubt the number of colleges of engineering has also increased, so that the total

increase in the number of students of engineering will probably be in greater proportion than is shown in the figures quoted. While the population of the United States increased 22 per cent during the period of ten years from 1890 to 1900, the national engineering societies increased in numbers 77 per cent in ten years and no one of them by less than about 50 per cent and the engineering colleges mentioned increased by 87 per cent, and the lowest percentage of increase was 51 per cent. Of the increased demand for engineers and for engineering education there can be no reasonable doubt.

Organized, as we are, to study and work out problems of engineering education, it is proper for us to inquire somewhat more specifically what is to be in the future the special nature of the demand for men educated in engineering; and further, what we must do to meet the demand successfully and in the best way.

As to the character of the demand for graduates in engineering, it can be assumed without question that in the future as in the recent past, for positions directly in engineering the graduate of the engineering college will in general be demanded, and that even more than in the past the positions of prominence, the prizes in the engineering field, will mainly go to the school-trained men. It will, no doubt, be true that the "graduate of the axe-handle," the self-trained man, will always occasionally reach the top, but more and more, as time goes on, will it be true that he reaches it only by somewhere, somehow, laying hold of those essential principles which form a part of the training in our best engineering colleges. The school-trained men will set the pace, not in all cases to the end, yet through the greater portion of

the race. An untrained man will have little place in engineering. Recently the demand for engineering graduates has been sufficient to absorb the whole output from the colleges of engineering. A year ago the evident demand was perhaps double the apparent supply. During the year past the demand appeared to abruptly drop, but there has been a notable revival; to-day it may be, temporarily at least, slightly inferior to the supply.

While it is not true that even the field immediately occupied by our graduates is exclusively engineering, yet their availability in the special education in which they have been educated, has dictated that a very large proportion do, as a matter of fact, continue in the line towards which their education has been directed. Employment in engineering has generally, but not always, proved the goal for the graduate. In many cases it has rather been the channel, the period of preparation or probation for duties of a somewhat different character. In an increasing degree it has been found advantageous and desirable to secure superintendents, managers, presidents, of railroads and other semi-engineering enterprises by promotions from among the school-trained engineers. The policy of that splendid railroad system, the Pennsylvania, has long since been established; the civil engineer engaged upon maintenance of way finds himself directly in line of the office of division superintendent, to whom in turn the office of general manager or even of president is in line and an evident possibility. A large number of mechanical engineering graduates are now entering upon railroad work; indeed, in many instances in the past they have been selected

to occupy the highest operating positions; there seems no reason why the prizes should not in future be fairly or evenly divided between the mechanical and civil engineers, while the rapidly increasing importance of electrical propulsion, and of electricity in signal work and otherwise, will shortly demand a knowledge of electricity which will give to the electrical engineer an importance in general railroad work sufficient to introduce a new element of competition which the civil and mechanical graduates must face. To my notion, a legitimate field for engineers is the occupation of all executive positions where engineering knowledge and skill are of immediate value, although the work is not immediately and directly the practice of engineering. I hope and expect to see this field constantly enlarging for the engineer and I desire that the engineer shall consider that the dignity of the profession does not suffer by his acceptance of such posts of honor and usefulness.

Another field open to men trained as engineers is that of contract work in engineering construction. To some this has seemed, in civil engineering at least, as a lowering of dignity. A somewhat broader view appears to be that methods of executing work are often more important as features of engineering than is the ultimate design. Furthermore, if the school-trained engineer-contractor does bring to his work greater skill in execution, greater pride in honesty of construction, and a better analytical understanding of the cost of various elements of the work, with diminution of the risk, and a consequent lowering of cost (as I believe he does) then the contractor is not and ought not to be, as sometimes in the past, in any sense a constitutional

foe of the engineer in charge, but rather a help, or better, an engineer legitimately in the practice of a special branch of engineering which ought properly to attract those whose abilities and tastes lead them to adopt it. In bridge work, machine shops, electrical manufacturing and installation, and many kinds of engineering, it has long been true that the standing of the contractor has been inferior on the whole to no other class of engineers.

New fields for men trained as engineers are opening daily; looking backward for thirty-five years, it appears to be true that the opportunity for employment for the large numbers graduated now, is definitely better than for the limited number of graduates at that early time. It is my judgment that the demand for engineers that comes from the development of engineering enterprises is due in very considerable part to the fact that there has been available, in increasing quantities, a supply of competent engineers, and this in turn to the fact that in this country the opportunities for engineering education have been more general, and its quality better, than in the earlier days. In investigating any question of demand and supply, it should be understood that not only does a supply generally follow a clear demand, but it is also true that an adequate supply of a good article certainly stimulates and often even creates a demand. This principle is seen nowhere more clearly than in matters of transportation, and especially in connection with transit facilities in large cities. In my own city of Boston, where successive steps have been from a half dozen independent lines to a consolidation of horse railways, to electric lines, then to a subway through the congested

section, afterwards to elevated lines to the suburbs, each step has seemed to give but temporary relief; the response in patronage which followed each improvement in the article of transportation has fully kept pace with the improvement, the demand has very promptly absorbed the improved supply which itself largely created that demand. While the population of Boston shows an increase of 25 per cent in ten years from 1890 to 1900, the number of passengers carried by substantially the same transportation company increased 62 per cent. Practically the same thing has been true in other cities and in other lines of transportation work.

In addition to the general principle just set forth, it is further true that in many instances individuals have largely or entirely created their own opportunities, and have often incidentally enlarged the general field of engineering opportunity and employment, so that the increased general demand has in many instances been due specially to the superior quality of the supply as shown by some individual engineer. The city engineer of a small city in Massachusetts failed to secure reappointment when a change of administration was made. He had given careful study to road construction, which was then receiving much attention, and at some apparent sacrifice at first, he continued to give special attention to this class of work, in which he attained acknowledged prominence. His influence was important in securing the appointment of the Massachusetts Highway Commission (of which he has always been the most active member and is now chairman) which has constructed about 575 miles of state highway; with an expenditure by the commission of more than

\$4,500,000, besides aiding largely in the impetus given to highway construction the country over. The engineer largely created his own opportunity, the supply created the demand in his case.

Two of the most important engineering projects in Massachusetts, the Metropolitan Water Supply and the Charles River Basin, are the results of careful work and able reports by an engineer who was recognized as an able investigator, but who appeared to be shelved from active construction in his position of chief engineer of the State Board of Health. The expenditure upon these two projects will be about \$28,000,000, and the engineer in question is either chief or consulting engineer of both schemes. The general opening of opportunities for many other engineers which has been created by these works has been of great importance to engineering. Instances of the man creating his opportunities could be multiplied indefinitely.

The field chosen by the individual for his opportunity is not always pure engineering. While the demand for engineering, the demand from engineering enterprises, the demand for engineering graduates, the demand for engineering education, is strongly on the increase; yet the day of trouble is before us, the day of financial crisis when enterprises languish, when the demand falls sharply off and the supply continues, although in diminished numbers. Then will come the time when the practicing engineer and the engineering graduate will find a necessity, not now existing largely, to make for himself his opportunity which will lie outside the established lines of engineering; when he must accept not what he would, but what may be

offered, and the engineering graduate will be forced into general business, into manufacturing. It seems reasonable that his greatest usefulness will first be found with dealers in engineering or mechanical supplies, or in manufacturing where engineering skill can never be amiss; already the demand in these directions has become a reality, rather than a possibility. Already some of the manufacturers' insurance companies employ a large force of men trained in engineering; life, fire and marine insurance constitute, likewise, reasonable fields. Banking, and the sale of stocks and bonds, are occupations to which in many instances engineering graduates have already found themselves adapted by the training they have received, and in which the line of study followed in the engineering college has been found frequently to be of practical advantage.

For the purposes of general business of various classes, if more than the high school course is to be attempted, what better preparation is available than what a young man receives in our engineering colleges, as the courses are now arranged? An old saying has it that man admires women for her beauty; woman admires man for his strength. In view of this saying, which has a large kernel of truth in it, the education needed for general business is one which shall give strength rather than beauty; the education which shall give intellectual vigor rather than mere finish; the education which shall early secure habits of industry, application, and definiteness of knowledge, rather than that habit of ease and comfort which seems almost essential to what we naturally think of when the word culture is used.

While there are always endless controversies in the educational field as to subjects and methods, there is recently much unanimity of feeling among our foremost educators that education should have as its object "training for power" as the expression is. Nothing in education is more important than that the student should be forced to think. The man who has experienced religion in a twinkling has no more surely caught a glimpse of a new world and a new life than the dull student who finally exclaimed to me, his tutor in a mathematical subject, "I see, you want me to use my good sense, and not my memory." He had seen the light; he was a dull student no longer, nor was I longer his tutor. Isn't it true that the old classical courses in our colleges, with history and language predominant, tend to train the memory far beyond all else; and that the engineering courses, with mathematics and science predominant, tend to compel thought? Do the academic courses in our colleges differ sufficiently from the classical courses in this feature to be free from the same criticism? A man becomes strong by virtue of the work he does, the exercise he takes; one measure, often a good one, of the efficiency of instruction, is the amount of work demanded from the student; a good measure of bad teaching is the amount of work assumed by the teacher which should fall upon the scholar. Without taking the above propositions literally, it is well known to those familiar with the facts, that the student in the engineering course cheerfully works much harder than his neighbor in the same college who has selected the academic course. Which student is securing the greater

strength? Which is essential for business, strength or beauty?

Not only do the studies in the engineering course tend strongly to secure from the student whatever advantages follow from thorough and interested application to work, but it seems also to be the fact that these studies, or many of them, are of the sort to supply the quality of training which a man needs in business life. The study of mathematics in lines advanced beyond the high school scope, must certainly be of value to the man who desires to have a grasp in matters of accounting and finance. The study of science trains him to observe facts and phenomena and to draw correct inferences and conclusions from such facts. The basis of science is not guess-work, but observed facts; business procedure, also, should be founded on a knowledge of underlying facts, and the successful business man should be he who successfully interprets these facts. The student of science interprets his facts in the light of law, the laws of nature; the business man must carry on his work in the light of law, of the laws of nature, of economic law and of business and legal restrictions. The engineering training is strongly analytical in its character; the graduate has learned to separate a problem into its elements, and to the controlling one he gives his immediate and special attention. In my mind, the successful analyst is more likely than others to have some synthetical power. The man whose analytical habits are well established is more likely than others to have some ability in organization. In modern business where consolidations are almost the rule, the prime requirement is successful organization. The

trusts, many of them, have failed of adequate success, often because the heads have been, in the nature of things, selected from the selling agents, the earlier salesmen whose training has been other than in the direction of organization, whose knowledge of nature's law as applied to manufacture has been practically nil. In this connection, it is interesting to know that the first great master of railroad rates, the first commissioner of the trunk line pool, still rated by traffic men as greater than any of his successors, was Albert Fink, first known as an able civil engineer, a bridge engineer, the originator of the Fink truss. In all large enterprises, the difficulty is to secure at once efficiency of organization. It was recently noted as a rare occurrence that the superintendent of motive power of a large system of railroads had organized his work so that on his return from a two weeks' trip, there had accumulated three letters only which required his personal attention.

To my mind, it is also true that the information acquired in the engineering course is likely to prove of value to the business man, although we all understand that this is not the important feature of the education. A knowledge of chemistry, of physics, of the properties and laws which determine the behavior of materials, a proper understanding of the nature and laws applying to the use of steam, electricity, and water wheels, or in other words, an understanding of power and its use; these at least constitute a resource for understanding and handling things material and mechanical, which ought to be of value to any business man and especially to those whose business has intimate connection in any way with manufacturing. To the scientific studies are

added, at least in very many of our engineering colleges, courses in history and economics, some familiarity with French and German, and in reasonable amount, the study of clear expression in English. Isn't it true that this training is strong in securing habits of application, strong in training the proper qualities of the mind, strong in the useful knowledge of facts and principles acquired? But beyond all this is the moral training, the training in character which is a natural result of an intimate acquaintance with science, of close contact with scientific methods and reasoning. The study of science is, it must be, the search for truth, and it must from usage cultivate a love for truth. That the scientific attitude of mind is of supreme importance as an element of character building seems to me on principle to admit of no doubt. As a matter of observation, I know of no class of men whom I believe to be less subject to business corruption than the civil engineers who have come more especially under my notice, and I do not doubt that the school-trained mechanical, electrical, and mining engineers are men of equally high character. The influence of training in mathematics and science is also calculated, it seems to me, to develop another important element of character. The student learns in mathematics that correct procedure will secure correct results. A clear appreciation of these truths naturally leads to the establishment of that quality of character which we call courage. An engineer unless he is trained so as to have acquired something of courage, is comparatively valueless. A very able editor in the engineering field once stated that an important value of engineering education is that it

enables one to look a fact in the face. It sometimes takes courage to do that. To me it seems most important that any business man should have learned courageously to look facts in the face; if the facts show not only present but also future losses as the result of continuance of a given policy or even of a given enterprise, the sooner the truth is known the better. Not all business men are proof against self-deception. And, again, I must believe that the man whose training has been the search for truth will not only be honest to himself, but will surely make some protest against continuance in any business whose only profit lies in dishonesty to his neighbor. It is difficult for me to believe otherwise than that business character is a good business asset in the long run, and that the engineering training which tends to promote a love of truth will work to the good not only of business as a whole, but of the individual himself.

There remains untouched the question of executive ability, about which there appears much confusion of mind. That the engineering graduate, by virtue of his years of study, has had his executive capacity impaired, I am unwilling to believe. The numerous successful executives who have come from this class is an assurance otherwise. To the contrary it has always seemed to me that executive ability consists in important part in a knowledge and appreciation of the things to be done, by others to be sure, under him. If a man by virtue of his education does have a proper appreciation of the behavior of materials, of the nature and use of power, of natural law, to my mind one of the requisites for executive ability has been largely secured. From

another point of view, it has seemed to me that the man educated as an engineer must have acquired, to be successful, the habit of investigating conditions and materials, and of devising methods of construction or operation dependent upon these conditions and materials. To the man trained in this way, the study of materials then becomes in part the study of men, the men with whom he has to deal, or the men upon whom he depends, and his training has done much to secure a second qualification for executive ability. That the great places are filled by men of inborn executive genius is no doubt true, but the geniuses are few and the positions are many, and these positions must be filled by men in whom, of course, the executive quality must not be definitely lacking, but by men of good parts whose training and experience qualify them otherwise to successfully fill them, and I believe that this means the men with the engineering training in which science and mathematics play a leading part. That the ordinary academic college training will generally serve the same purpose I see no reason to believe.

The part played by scientific training or the scientific habit of mind is important. A year or two ago, an after dinner speaker connected with one of our great universities, in addressing a body of engineering trained men, cited the case of Michel Angelo, apparently to show that the influence of art had made him so broad and able that among other distinctions, he was, as is well established, very eminent as an engineer. To me it occurred at that time that the value of any fact depends upon deducing from it the proper conclusion, and it seemed to me then, as now, that engineering as

a science might have value on a basis or an element of successful art, while artistic skill was far less likely to constitute an important basis of the science of construction. To me it appeared to be an example of the value of an engineering training even to the unrivaled artist. One of the foremost artists of Boston is a graduate from a course in mechanical engineering and believes the training to have been very valuable in his work. There are many fingers pointing to the value of a training in science as the one thing needful to make the man who shall rise above his fellows. Following this idea it is an interesting coincidence, if it be no more than this, that President Eliot of Harvard was, before assuming the presidency, for a number of years an experienced teacher of mathematics and chemistry. The reputation of President Hadley of Yale was established as a lecturer upon railroad transportation, and as a member of the editorial staff of the *Railroad Gazette*, and his first lectures on the subject were delivered at a prominent engineering college. President Van Hise, the recently elected president of the University of Wisconsin, is a geologist and took the engineering course at Wisconsin; President Remsen of Johns Hopkins is a chemist; President Jordan of Leland Stanford, Jr., a biologist; President Schurman of Cornell holds, among others, the degree of doctor of science from the University of Edinburgh.

In my judgment, not only is it true that graduates of engineering courses will find it necessary to enter into the field of general business, but I believe that their success will be sufficient so that this necessity will be most fortunate for the cause of what we are all inter-

ested in as engineering education. With the increased activity which will follow, broader fields will open out, and other important outlets for our graduates will be recognized and accepted. In the Boston public schools, college graduates only are eligible to the desirable positions for men. These men are now mostly graduates from the academic courses and as a rule highly trained in the classics rather than in science and mathematics. Large numbers of young men enter college well knowing that their first employment after graduation must be in teaching; many never leave this field. At present very few of the graduates of an engineering college are content to teach, unless in professional subjects in technical colleges and comparatively few even there. When the time of stress arrives, teaching, as well as general business, will prove attractive and engineering education will reap a benefit from having the work of preparation in the hands of teachers interested in engineering, and trained most effectively in science and mathematics. The "head master" of a grammar school or the "master" of a high school in some of our large cities receives a salary not inferior to that received by the majority of the faculty of most of our colleges, academic or engineering; the position is practically permanent, the opportunity for usefulness great, and the dignity sufficient so that many of our graduates might well look to teaching, provided their tastes and capacities indicated that as a proper vocation.

With the growing importance in the world of matters engineering and mechanical, there must also be a demand, constantly increasing, for journalistic work, not only for technical periodicals, but in newspapers and

general publications. Not only on the side of an appreciation of the technical or engineering application of many matters of interest to the public, but also upon the literary side, there is no reason why engineering graduates should be at a disadvantage. If the engineering training tends to clear thinking, as we believe it does, it ought also to tend to clear writing. A clear view of an idea to be expressed is the first requisite to clear expression. The engineering training tends strongly to secure not only clearness, but it seems to me simplicity of style, and if these be secured, little else need be desired.

If the field of employment for graduates in engineering is to be in effect what has been set forth above, what shall be the character of the college of engineering in the future? For the present, at least, the college of engineering as now commonly organized for undergraduate work seems to be very efficient and to reasonably meet the demands and requirements of the engineering profession. Will it continue to do undergraduate work or will it become peculiarly a professional school, and open only to graduates of colleges (academic or engineering) at that? In my view, the great demand will be permanently for the engineering college doing undergraduate work; whether as a preparation for engineering proper, for semi-engineering or non-engineering executives in the conduct of large enterprises, for positions in general business life, or for the work of teaching. That there will be a moderate (but perhaps a limited) demand for engineers trained well beyond what is possible in a four-year undergraduate course, is to me a proposition whose truth can

not be questioned, but that the great body of engineering graduates should be as highly trained admits of serious doubt. Engineering differs in some points materially from either medicine or law. Engineers rather more commonly than otherwise work in corps, and the larger proportion are subordinates to the engineer in chief. The doctor of medicine largely stands alone, the responsibility is distinct and must be promptly met by the individual without the opportunity, ordinarily, for consultation. The importance of securing the highest possible efficiency in the surgeon or the physician can hardly be overestimated. Here the logical outcome is not only a graduate professional school, but beyond this, one having entrance requirements which shall demand, for undergraduate accomplishment, work of a sort to form a suitable foundation for the additional professional work. With law, while the work is largely individual, the importance of graduate preparation is less apparent, the necessity even for the law school at all is far less urgent, although its desirability should not be questioned. Private reading with a minimum of direction can be counted on to secure most excellent results. A training in business will form a more valuable foundation for the practice of law than a general college training. For either professional school a four-year college course is of evident value, especially in securing a knowledge of how to study. For the requisite training of mind, the acquirement of diligence and concentration as habits of study, for the development of the analytical quality of mind, which are what are needed for any higher school, the engineering course for an undergraduate course will some day be recognized as bet-

ter than the academic course as a preparation for the study or the practice of the law.

Whenever the demands of engineering require men trained farther and higher for the more important positions, how shall the work be done? In purely professional schools open only to college graduates? Possibly, but if so, for the best development, these graduates must be men well trained in science and mathematics, trained very much as we now train the men in our undergraduate engineering courses. The logical outcome appears to be, not the professional engineering school or college, but rather a development of graduate work, the granting of the advanced degree, with the advantage not only of building upon a foundation sound and sure, but also of attracting and developing mainly those men only whose demonstrated ability shall have established a probability of worthiness sufficient to secure the advanced degree, the survival of the fittest. Not only does this seem the logical development, but in this country also it is the actual development as it is taking place in several of the foremost schools of engineering.

In a former presidential address, some comparison was cited as to the growth of the engineering college as compared with schools of medicine, of law and of divinity. From my point of view, that the great field of the engineering college is to be that of an undergraduate college for the general training and education of young men (and not purely a professional school), some data as to the comparative growth of engineering and academic departments may be in point. At the University of Wisconsin, in ten years from 1893 to 1903,

the growth in the academic department is from 628 to 1,122, 79 per cent; engineering, from 174 to 582, 234 per cent. The actual increase from 1903 to 1904 was academic 85, engineering 155. With a larger proportional and of late years a larger actual increase, before many years the engineering department will have out-run the academic. Indeed, at Cornell University, where there was an opportunity for an even start, not only have the engineering colleges grown more rapidly than the academic, but the total enrollment shows in 1903 a total for the engineering (including architecture) of 1,196 and for the academic but 795. What is true of Cornell University is true of many other colleges. Even at old Harvard, with its age, its influence and its traditions, the number of undergraduates in the academic department increased from 1,449 in 1893 to 1,936 in 1903, or 34 per cent, while the Massachusetts Institute of Technology, less than forty years old, shows an increase of 51 per cent, with a total of 1,599 in 1903, not only a larger proportional but also a larger actual increase in the last ten years. The Lawrence Scientific School of Harvard University also shows a large growth, from 181 to 584, in the same time, an increase of 223 per cent, although a smaller actual increase. That the undergraduate engineering courses in our colleges are destined soon to outstrip in numbers the academic, I do not entertain a doubt. Indications are not lacking that, taking the country as a whole, that result may have already been accomplished. That the engineering courses furnish a superior training is my firm conviction. The field is, or is to be, ours and with it

increasing responsibilities, increasing dangers, against which we must guard.

Let us look at some of the requirements. In the future, as in the past, the training is more important than the particular matter taught. It is not what a man knows, but rather what he can do, or still better what he is capable of doing rather than what he can do at once; and this comes very close to meaning what he is.

As has been well pointed out to this Society, the professor of engineering must be above all else a teacher; although an engineer as well, in any case a teacher; to this end, whatever may be done in the academic college courses, the engineering colleges should have some system of inspection and supervision, adequate and critical, something equivalent to the inspection found necessary in preparatory schools. That the teacher of engineering should do good teaching should no longer remain a matter of chance. Furthermore, the eye and the hand must be trained as well as the memory and the other faculties of the mind. The subjects taught and the methods of presentation must have as their prime objective the training of the mind and other faculties to power and precision. Mathematics and science must find most important places. In order that the proper value of science and mathematics may be secured it is generally necessary (as human nature is constituted) that they be applied, as they are applied in engineering. This in my view constitutes a line of demarcation between the engineering and the free elective academic course, which it will always be difficult to eradicate.

The direction taken in the application of science and mathematics is of minor importance, whether civil, or

mechanical, or electrical, or mining engineering, or whatever else it may be. It is important that the work be carried far enough in its application to be effective in enforcing and illustrating theory and in developing in the student the power of attack, whose importance has been well discussed in this Society.

The greatest danger comes from the pressure, both from within and without, to include in the engineering course this, that, and the other thing whose usefulness in engineering has been demonstrated. Already this pressure has reached beyond a tendency; many engineering colleges have experienced and are now experiencing the reality of teaching too many things, with the result of creating greater complexity than is consistent with the best results. Not only is there danger of trying to teach too many subjects, but there is a further tendency in the direction of trying to teach too much of any subject in a given time. The important feature is to do thorough work as far as it goes. It is easy for most of us to magnify the importance of the subject matter which we teach.

It must be clearly realized by educators, it must be convincingly explained to practitioners, that the engineering college is not intended and can not be expected to bring to its graduates a knowledge of, or even an acquaintance with many subjects most essential to the success of an engineer. The problem is rather to utilize a limited period (at present four years) in training the student, in developing his capacity for understanding matters engineering, so that as opportunity offers he may develop into the successful engineer. On one side is the clamor for attention to cul-

ture, on the other for information courses of various sorts, often with little or no training value. Most of what we regard as culture must depend upon environment and habit and must be acquired outside the college walls, in the home, the club, the church. Very little of real culture, little more than a taste for it, can be acquired directly from the work of instruction in the small fraction of time properly available from most college courses, academic or engineering. Little in the way of experience or information can be securely acquired in an engineering course, and little should be attempted. The engineer as employer, the manufacturer as employer, must come to realize that upon him rests the necessity of providing his promising employees the opportunity to learn business methods, to acquire engineering experience. The graduate must understand that the college has not educated him, but has provided a foundation firm and strong upon which he may educate himself so as to become a competent engineer and a cultured gentleman. The problem for the engineering teacher, for the engineering college is no more, no less, than to provide this foundation which must have breadth, but also depth and solid fiber throughout. The success of engineering education depends upon the steadfast maintenance of this attitude as to the function of the engineering college, as its part in the making of the man and the engineer.

A PRACTICAL METHOD OF INSTRUCTING ENGINEERING STUDENTS IN THE BIOGRAPHY AND HISTORY OF THEIR PROFESSION.

BY ROBERT FLETCHER,

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Concerning the proposition that a concerted effort be made, under the auspices of this Society, to promote the publication of a series of books on the history and biography of the engineering profession, the following suggestions are submitted:

It has been asserted that the rising generation is lamentably ignorant of the history of engineering and of the engineers; also that there is very little at present available in printed form for supplying the deficiency. It is easy to be extreme in such statements. Doubtless the extent of such ignorance is great enough to be very regrettable, but not so complete as some assume. Moreover, the material for supplying the lack, while scattered and unrelated, makes a respectable showing in the aggregate. On the latter point an impromptu inventory would include the following: Smiles' "Lives of the Engineers," in five volumes, making us acquainted with about eighteen engineers and inventors, chiefly English (Murray, 1874); a separate enlarged memoir of George and Robert Stephenson (Harper & Bros., 1868); "Civil and Military Engineers of America," by Stuart, twenty memoirs (D. Van Nostrand, 1871); Memoir of Loammi Baldwin (omitted by

Stuart), Geo. L. Vose, 48 pp., Boston, 1885; memoir of Geo. W. Whistler (also omitted by Stuart), Geo. L. Vose, 45 pp., Lee & Shepard, Boston, 1887; biographical sketches of the three Stevens and three other engineers, by J. Elfreth Watkins, National Museum, Washington, 1892; memoir of Horatio Allen, by M. N. Forney, reprinted from *Engineering and Railroad Journal*, 48 pp.; memoir of John Ericsson, by Wm. C. Church, 2 vols., 8vo, 1890, Scribners; memoir of Jas. B. Francis, by Hiram F. Mills, 8vo pamph., 8 pp., 1892; an autobiography by James Nasmyth, edited by Smiles, Harpers, Franklin Square library No. 299; history of the growth of the steam engine, by Thurston, 478 pp., D. Appleton & Co., 1891,—which should be “required reading” for every engineering student, as an indispensable item of his education; numerous sketches and short memoirs in *Engineering News*, *Engineering Record*, *Engineering and Mining Journal* and *Transactions of American Society of Civil Engineers*, including such names as Chas. S. Storrow, W. Milnor Roberts, Ashbel Welch, Jas. B. Eads, C. Shaler Smith, A. L. Holley, Bessemer and others whose distinguished careers,—usually identified with original advances in engineering practice—were closed during the past quarter century. Less accessible, but available in some libraries, are : Rickman’s “Life of Telford,” 4to, 744 pp., London, 1838, Payn & Foss; a life of Thomas Brassey, the famous English contractor and engineer, by Arthur Helps, 1872; works of Perronet, large folio of sixty-six plates, 1782, with descriptive text, large quarto, 634 pages, published in 1820, Didot, Paris.

Here certainly is a partial showing of matter either

ready to hand or easily made ready with no great labor.* The instructor who appreciates and is in full sympathy with the past of engineering and its leading personalities will not find it difficult to kindle the interest of his students in that direction. If a demand were created it might be possible to have some of the above-named works and others re-edited and reprinted so as to be made immediately useful.

But there is undoubted need of undertaking a rather extensive work in the collecting, digesting and editing the large amount of new material now available—as well as the recasting of some of the old—so that the history and biography may be made more complete, and presented with more method and uniformity.

To accomplish such a result most effectively it is important to adhere to two working principles, viz., *brevity* and the placing of large *emphasis on the personal element*. Considering these in reverse order, we recall what has been well said in another connection: “The student (of nature) will find that the best way into any science is through the history of the discoveries that have made it a science. By following the footsteps of those who have found their way to the truth, we pursue natural, if seemingly vagrant, paths. The difficulties of discovery that the pioneers of the science met are the difficulties that the student encounters. Moreover, there is a human interest about the struggles of a man with the problems of the world that adds much to the hard facts of a science, and gives one of the needed

* More than twenty years ago the writer prepared, for use as an introductory lecture to students coming under his instruction, a pamphlet entitled: “Lessons from the Characters and Achievements of Great Engineers.”

graces to the stern features of any physical inquiry.”* To state it in brief, the story of the achievement is not complete without a near view of the life, character and spirit of the man. Smiles in his “Lives of the Engineers,” has created inimitable models of such biography. His historical setting is complete in background and foreground. He conjures the whole environment into view. His subjects become to us like personal friends or near neighbors. So with the proposed series. Around each period marked by some new invention, or distinct advance in process or method, should be grouped the chief exponents, through whose labors, trials and triumphs the increment to engineering science and practice has been made. Mentioning instances at random, we may specify the Roeblings, father and son, in connection with wire suspension bridges and the wire rope industry; Wernwag, Burr, Towne and Howe, identified with the distinctly American timber truss bridges of the last century; Whipple, Linville. C. Shaler Smith and others in the development of the standard types of truss bridges of iron and steel; the Stevens family and Fulton in relation to the early stages of the development of steam navigation, marine-engine practice, railroads and armored war vessels; Bessemer, Holley and the other great metallurgists whose names must not be separated from the story of the building up of the great iron and steel industry; etc.; etc.

Secondly, the principle of brevity is so obviously necessary in executing this task that little need be said on this point. To assume as a basis a bare list of the

*Shaler and Davis, “Illustrations of the Earth’s Surface.”

various classes of engineering construction and operations, and proceed to prepare mechanically a series of formal "histories" crammed with chronology and statistics would give but imperfect results. Twenty-seven separate titles were suggested in the original proposition. Some of these and others not named might be grouped either according to time or topic. It will be confessedly a difficult task to clothe all these with a living interest. Evidently the style of Smiles is worthy of imitation but the scale and scope of his treatment must be greatly reduced. It is suggested that a few large works like Thurston's "Growth of the Steam Engine," in a terse but comprehensive style, would properly cover such epoch-making developments as some that have been mentioned, and might include a rather wide range of personal history and incident. Also that for some biographies small memoirs of from 50 to 75 pages octavo, like Vose's "Memoirs of Loammi Baldwin" and Maj. Whistler, would be quite sufficient. In some cases where there is only enough material for a few pages for each one, a classified group might be included in one volume.

A third principle should govern the method and style of presentation, viz., *progress is best appreciated by contrast*. Statistics, reduced to the necessary minimum and presented graphically when possible, and the chief outlines of situations which mark important epochs or periods, vividly contrasted with the situation at the opening of the twentieth century, would tend to give definite impressions more easily retained. The aim, steadily kept in mind, must be to give the student a continuous view of essential features of the past devel-

opment so that he may intelligently view the present in relation to the past, and fill in the details for himself as opportunity occurs.

Finally, facing the question of practicability and promise, it does not seem likely that we shall be favored with such a series at an early day. To have such work well done *to order* would be difficult, though not impossible, if the right persons could have proper inducement and opportunity offered to undertake it. Usually such work is done in the best way as a labor of love. The gathering of the necessary data is commonly a slow process, but might be hastened by systematic effort under favoring conditions. An extensive series would not be likely to command a sale sufficient to cover the cost of publication—another reason for reducing the aggregate volume of the work to the smallest dimensions consistent with suitable treatment. If results are to be secured in the near future, evidently the work must be taken in hand promptly by an authorized committee or board of collaborators, with an editor-in-chief, working according to a well-devised plan which would determine the general scope and character of the work as a whole. Considering the time and close attention which such labor demands, probably some compensation would have to be provided for one or more members of the board. The question of providing for the cost of publication might prove a serious one, as the risk would be considerable.

Leaving any further discussion of the general proposition, which has been confided to a committee, a few considerations on the topic stated by our title will be sufficient to show how the present situation, with its

limitations, and drawbacks, may be treated. This is a statement of what has been done already, including suggestions of what might have been done with a little more time and attention given to the subject.

On the library shelves, accessible at all times to the students, are some of the memoirs before-named: those of Smiles, Stuart, Church's memoir of Ericsson, works of Perronet and Telford, Smeaton's Reports, Smeaton's Edystone Lighthouse, and some shorter memoirs of recent date. At the proper time a general lecture is given concerning the importance of some familiarity with the history and biography of the profession, and the reading of some of the works referred to is recommended. Again, in connection with the course in thermodynamics and heat engines, Thurston's "Growth of the Steam Engine" is made required reading. Into pamphlet cases marked "biography" are placed, from time to time, as received, biographical sketches or memoirs in pamphlet form, and clippings giving any noteworthy facts concerning the lives and experiences of engineers or contractors. Occasionally, during the year, selections appropriate to the subject before the class are made from this material, to which the speaker adds personal incidents or facts within his knowledge and experience. Recourse is had also to the numerous biographical sketches which appear or have heretofore been given in the leading periodicals, some of which are especially suitable in one connection and some in another. Thus the material now available is and may be used to gain a fairly good, though perhaps a scattered acquaintance with the "worthies" of the profession, both of past and present time.

It is very much to be regretted that some of the old engineers who have recently passed away—Chas. S. Storrow, Jas. B. Francis, Ashbel Welch and others—were not persuaded in season to prepare reminiscences of their lives and times for the benefit of posterity. The late W. Milnor Roberts prepared a very satisfactory paper of that sort (*Trans. Am. Soc. C. E.*, Vol. VII., pp. 197–215), only that the reader wishes it were longer. Nevertheless, some research reveals a considerable amount of such material scattered in discussions of papers read before engineering societies, and in engineering periodicals. This, when found, should be carefully indexed for use in this connection.

Finally, it is suggested that those who have indexes of such material might be willing to use them for the common good by giving the data to a committee of the Society who would edit an index embodying results of all researches made, and distribute to all interested members. If it should be deemed wise to undertake the larger task proposed this would be a good preliminary work for that. Enough has been said to show that we are not in a desperate situation if we make good use of what we have. But our fellow member did well to call attention to the growing deficiency in this important line of knowledge and the undoubted tendency to slight it in the engineering schools and colleges.

A BUSINESS PROPOSITION.

BY J. A. L. WADDELL,

Consulting Bridge Engineer, Kansas City, Mo.

SOME SUGGESTIONS AS TO HOW THE EFFICIENCY OF THE SOCIETY MAY BE INCREASED.

It is possible that some of you do not know that this Society either is or ought to be one of the most important societies in the world. If you will consider the matter for a moment, you will readily see that the statement made is a fact; for it is now almost universally acknowledged that engineering has become the most important of all the professions, in that the material progress of the entire world is dependent upon it; and upon this society depends the efficiency and thoroughness of the education of the young men who are destined to become its members and to perform its functions.

As to whether the society has yet attained its highest possible state of efficiency, there will be no division of opinion among the members. Both its newness and the small size of its membership make it apparent to all that its great work has really not yet commenced. On the other hand, the amount of good that has been accomplished by this organization during its short existence is far more than even its own members imagine.

Hitherto the policy has been for the members (who are mostly professors) to write papers on various subjects connected with engineering education, present them for a rather meagre discussion, and have them

printed with the discussions in the "Proceedings." The benefits thus effected are almost entirely confined to the impression made by these writings upon the minds of the members who read them and who endeavor to take advantage of the suggestions they contain.

As yet the Society has made no great organized effort to effect improvements in the methods of teaching engineering; nor has it yet inaugurated any important investigation or literary work.

Last year it was formally suggested that the Society undertake the compilation and editing of a history of civil engineering; but beyond appointing a committee to look into the matter nothing has yet been done, and the probability is that the scheme will soon die a natural death, unless the promulgator of the idea takes hold and pushes the Society into action or else brings it to the attention of some other organization. Such an undertaking as the one referred to is eminently the *métier* of this Society. No other organization is so well fitted to undertake it and push it to a successful conclusion. It would be well, therefore, for the Society to give the matter further consideration and ascertain whether there is not some practicable way for it to produce under its auspices a concise, complete, and authentic history of engineering, in all its branches, that can be sold at a price which will place it within the means of young engineers and students at technical schools. If the preliminary investigations were placed in the hands of three, four, or five members, all of whom are in sympathy with the movement and who do not reside very far apart, and if they were given formal authority by

the Society to act for it in raising funds to cover the cost of publication, some practicable working scheme might be evolved; and, if the work of this committee be successful, it would be well to continue its existence and to delegate to it the remaining work of compiling and editing the book.

There are five members of the Society, all residing within a small radius, who have expressed their readiness to serve on such a committee, and who feel confident of their ability to materialize the project.

One of the first steps for this Society to take in order to develop a great sphere of usefulness is to increase its membership. Every full professor of any branch of engineering in the United States and Canada ought to be on the list of members; and there should be established a grade of associate membership to include as many as possible of the junior professors and instructors in engineering as well as those teachers who make a specialty of preparing young men to enter the technical schools. Besides, there should be taken into full membership as many as possible of the prominent practicing engineers in all lines of work; and young engineers should be encouraged to enter the associate grade with the expectation of becoming later full members.

The way to increase materially the membership is to appoint a special permanent committee for this purpose and to give it *carte blanche* about choosing new members and associate members, an invitation from the committee being equivalent to election to the Society. If the committee be selected with proper care, there will be no danger of the Society's reputation and standing

suffering because of the admission of undesirable persons.

The professors of engineering and the prominent practicing engineers should be approached with the flat statement that they are delinquent in their duty to the profession if they fail to join and aid this praiseworthy organization in the accomplishment of its high aims and objects; and the instructors and younger engineers should be appealed to not only on the score of duty but also on that of self-interest; because the fact of belonging to such a society would benefit them professionally both from the mere fact of membership and from the opportunity offered to meet the older members and to take part in the discussion of important educational matters. It is within the realms of possibility by this means to increase the membership four fold within the short period of a twelvemonth.

The dues of this Society are not large enough. Three dollars per annum barely cover the price of the bound volume of the "Proceedings." On account of the small salaries of professors it would not be advisable to raise the dues to anything like the size of those usually charged by other technical societies, but surely five dollars per annum for full members and three dollars for associate members would work no hardship on anyone. With the extra money raised by the increased membership and the higher dues, many important steps could be taken by the Society that are now impracticable for lack of sufficient funds.

An innovation that could be made with great advantage to the work of the Society would be an arrangement by which business could be done by some other

means than waiting for an annual meeting in order to propose a measure, then waiting again for the next annual meeting for a committee to report. If a business committee were appointed, all the members thereof residing within a small radius, it could receive all suggestions, consider them, and either reject them or bring them before the members for ballot by means of letters stating all the pros and cons. If the proposer of a suggestion were not satisfied with the action of the business committee, he would, of course, have the privilege of bringing it before the Society at its next annual meeting, where it would be acted on in the present customary slow manner.

An arrangement by which the annual meetings of the Society would be held either jointly with or directly following those of the American Society of Civil Engineers would result in bringing into close relationship two technical organizations that ought to be most intimately allied. There can be no question of the correctness of the statement that the interests of this Society are more closely related to those of the American Society of Civil Engineers than they are to those of any other technical organization.

The most efficacious method for this Society to transact its business and to accomplish results of value is by means of a number of permanent committees. Several such have already been suggested, but others might be added, making the list about as follows: Business committee, membership committee, finance committee, preparatory school committee, other committees for special objects.

One duty of the finance committee would be to endeavor to secure for various proposed works of the Society financial aid from some of America's generous millionaires, who have money to devote to any objects that will result in the advancement of their country or of mankind in general.

The idea in having a preparatory school committee is to effect many greatly needed improvements in the preparation of young men for entering the technical schools.

DISCUSSION.

PROFESSOR MAGRUDER: Professor Waddell has made a number of suggestions concerning the kind of work which this Society should perform, and has repeatedly criticized the members for not doing more for the promotion of engineering education. I would respectfully suggest to this year's nominating committee that the gentleman be nominated and elected an officer of the Society, in order that he may be induced, not only to attend meetings himself, but to put in a few hours of time with the council where he can have an opportunity of inaugurating the work which he seems to think has been neglected. I would also suggest that he be added to the Committee of Industrial Education, of which Professor Williston is chairman, in order that he may have a chance to do some of the work which he blames us for not having done in the ten or eleven years we have been in existence. I believe that after he has experienced the difficulties peculiar to gathering the information which he is requiring of us, that he will better appreciate the inordinate amount of labor and expense involved.

THE PRESIDENT: Mr. Waddell's suggestion is a history of engineering; Professor Fletcher's idea is in part to call attention to what has already been done in the history of engineering. The most striking feature of Mr. Waddell's paper is the lack of knowledge he displays of the work and the activities of this Society. Mr. Waddell is a busy man. I do not remember that he has been present at our meetings, although he is evidently interested in what we are doing. It seems to me that he is not in touch with the situation as we find it. There has been an active campaign in securing new members. He is disposed to hold us to task for not combining with the American Society of Civil Engineers in holding our meetings. The activity of this Society has been exerted already as fully as possible to that end, and if anything more is to be accomplished in that direction Mr. Waddell should approach the matter from the other side. Last year this Society held its meeting in connection with another national engineering society, the American Institute of Electrical Engineers; the arrangement proved very satisfactory, our relations were exceptionally pleasant throughout. One very agreeable outcome of that meeting has been that the President of the Institute at that time has this year become a member of our Society. Professor Arnold, the president this year, is also a member.

To put the matter with greater technical accuracy, the Institute of Electrical Engineers showed good judgment—good judgment being characteristic apparently of their work in general—in selecting for their president a man who had been for a long time a member of this Society.

PROFESSOR A. N. TALBOT: Concerning the point here made by Mr. Waddell about the transaction of business throughout the year, he may not be familiar with the fact that nearly all of the business of the Society is transacted by the Council and by the officers of the Society, and that these bodies carry on the business throughout the year. Last year the proposed change in the Constitution by which members may be elected in the interval between meetings was referred to the officers for formulation.

PROFESSOR JACOBY: I think that Dr. Waddell has underestimated the cost of such an important undertaking, and the amount of labor involved in gathering the necessary material. It is not simply a question of collecting material that is scattered about in engineering literature, nor in doing the excellent work to which Professor Bull has referred. A great deal must be gathered from first sources, and anyone who has attempted such a task must know how difficult it is, and how much time it requires. I have made some effort to induce men like Mr. Linville and the late Mr. Latrobe to write reminiscences concerning important work done by them, as well as by engineers with whom they have been closely associated, because they could give us valuable information which no one else could supply. Mr. Linville stated that his library had been consumed by fire, and he had no records left except those which are in the possession of the Keystone Bridge Company. This historical work means travel and time, and the expenditure of money. It is a work that may take years, and will require cooperation on the part of many persons.

THE PRESIDENT: Perhaps it ought to be said that, at

the time the American Society for Civil Engineers was at work trying to organize a general engineering congress, an invitation was extended, not merely to the American Institute of Electrical Engineers and some other bodies, but also to our Society, to meet for the purpose of determining what could be done toward organizing this general congress of engineering. I deemed it wise to be present at their meeting. The date selected, October 3, was late, too late for our meeting, but I was particular to express to those present the feeling that this Society would do whatever it could, in every way, to advance the interests of the Congress. The situation was such, in many ways, that the other societies, notably the Institute of Electrical Engineers, and the Society of Mechanical Engineers, concluded it was not wise for them to join in promoting that congress, and the general scheme was abandoned. There is to be a congress of engineering carried on by the American Society of Civil Engineers alone, and as president of this Society I furnished them at their suggestion the names of Professor Robert Fletcher and Professor C. M. Woodward to present papers on engineering education. Professor Fletcher is to give a summary of the history of engineering education during the last ten years, and Professor Woodward is to do the same work with reference to manual training. Something, therefore, has been done in a favorable way.

THE CROWDING OF THE CURRICULUM.

BY ALEXANDER C. HUMPHREYS,

President of Stevens Institute of Technology.

In response to the request of our president, I had about decided to write a paper under the title of "The Crowding of the Curriculum," when I received a copy of Dr. Waddell's address, "Higher Education for Civil Engineers," recently delivered to the Engineering Society of the University of Nebraska; the reading of this able and suggestive address finally decided me to write this paper.

I am in doubt whether Dr. Waddell wishes us to understand him as intending his views to apply to engineering education in general, or only to the education of the civil engineer, using the latter term in its more restricted sense to describe an engineer engaged in one branch of our wide-spreading profession.

In the third paragraph from the end he says:

"When one considers that the true progress of the entire civilized world is due almost entirely to the work of its civil engineers, the importance of providing the engineering profession with the highest possible education in both theoretical and practical lines can not be exaggerated."

This can be accepted as true only if we understand the term "civil engineers" to include also mining engineers, electrical engineers, mechanical engineers, hydraulic engineers, chemico-electric engineers, sani-

tary engineers, ventilating engineers, architect-engineers, etc.

Again, in the sixth paragraph from the end Dr. Waddell refers to the necessity for the inclusion of at least thorough elementary instruction in mechanical and electrical engineering in his proposed post-graduate school. Such a post-graduate school should cover the whole broad field of engineering and therefore it should not be known as a post-graduate school of civil engineering unless we by mutual consent agree to use the term civil engineering to cover the whole field and agree upon some other term to cover the specialized line of engineering indicated by the college course in civil engineering.

While I find myself generally in accord with Dr. Waddell as to the desirability of improving our methods in engineering education, I find that I can not always follow his suggested means for effecting these improvements, nor do I agree with him in looking to the schools to supply so much of what the engineer must finally possess.

I shall not attempt an exhaustive discussion of Dr. Waddell's paper, though I believe great good would result to the cause to which this Society is devoted if it could be exhaustively discussed by the members of this Society and all others interested in this most important subject. Such a discussion would practically open up every branch of the subject. I shall, then, only attempt to give brief expression to my views on some of the points made by Dr. Waddell.

In considering all questions in engineering education, I first do so from the view-point occupied by Dr. Wad-

dell, viz., that of the man who has had a long, practical experience in the field of engineering and has constantly availed himself of the opportunities to judge of the efficiency of the educational methods employed by closely observing the results obtained in the persons of many technically educated employes. The opinions so developed I am now able to amend and supplement by study from the view-point of the educator.

Dr. Waddell very properly points out that it is daily becoming more necessary that the engineer should have at the same time a broader and more thorough training. He refers especially to certain marked weaknesses which should be corrected, viz., the almost unanimously acknowledged insufficiency of command of the mother tongue, the lack of training in systemization, inaccuracy and lack of neatness in computations, the failure to recognize that engineering work must be limited and controlled by pecuniary considerations, the impractical character of much of the instruction in the drawing-room and insufficient blending of theory and practice. He then goes on to specify certain subjects not covered in the usual curriculum of the civil engineering school, or if so included, inadequately treated, as follows: Political economy, law, business, history of engineering, oratory, dictation, specifications and contracts, graphics, secondary stresses, economics, science of railroading, geodesy, least squares, instrumental work, architecture, geology, tunnelling, and dams. He continues: "To this list might be added some other subjects which are often given, but which are capable of considerable extensions: for instance, metallurgy of iron and steel, harbors, canals, river improvement, sanitation, water-sup-

ply, power-transmission, highway engineering, mechanical engineering, electrical engineering, and steel-and-concrete construction." This is followed up by the statement that "both lists are, no doubt, very incomplete; nevertheless, they are amply large to show that there are many important branches of our profession which are either taught inadequately or are not taught at all in the technical schools of America."

In answer to the question: "Is it necessary for every engineering student to learn all of these branches?" and to the statement: "In his active career he will confine his attention mainly to two or three lines," Dr. Waddell replies: "Certainly, no man can specialize in many branches of engineering work; but the student of a technical school does not know for which lines he is fitted or which specialty circumstances may induce him to adopt. Moreover, every specialty in engineering is more or less closely allied to all other specialties; consequently it behooves a broad-gauge engineer to become somewhat familiar with all branches of engineering so as to act intelligently when his business involves him in other specialties than his own."

Dr. Waddell then by way of example points out how the bridge specialist has to face problems in mechanical engineering, electrical engineering, etc. He gives other examples.

Dr. Waddell tells us that professors of civil engineering to whom he has suggested these improvements and reforms in technical education, while generally agreeing with him as to the desirability of these changes, have claimed that there is not sufficient time for their adoption.

Dr. Waddell then suggests as a partial remedy the lengthening of the regular engineering course to five years.

In this connection let us quote from a previous paragraph of Dr. Waddell's paper:

“ But, great as may have been the strides in engineering education, the advance of the science and art of engineering has been far greater; *and this divergence of progress is steadily increasing.* The mass of technical literature which is of value to engineering students is now immense, *and is constantly augmenting;* while in my student days it was difficult to find enough good technical works to furnish us with proper textbooks for our course.”

The italics are mine.

In view of the facts as stated by Dr. Waddell himself, I contend that the extension of the regular engineering course from four to five years can not effect a permanent remedy.

It seems to me that the time has come for engineers and educators to recognize that this “ divergence of progress ” must continue. If, then, a five years course is urged to-day as an important element in the remedy for our present faults, then before many years a six-, seven or eight years course would be found insufficient.

Also, has not the time come for us to acknowledge that many of our curricula are already overcrowded, and as a result our present-day graduates are not more efficiently prepared for practical work in the industrial world than were the men graduated ten or twenty years ago? Thoroughness has in many cases been sacrificed

in the efforts to keep up in this hopeless race with progress in the sciences and arts.

Is it not true that many of us are apparently working on the theory that we can so improve the methods of the schools as to bring the graduates of to-day up to the level we have reached after twenty, thirty, forty, or fifty years of struggle and practice?

Not only are the courses in our best technical colleges becoming crowded at the expense of efficiency, but I am strongly of the opinion that the same criticism applies to the preparatory and other schools.

For a solid education in any branch of engineering, first of all, is required a solid foundation of the elements of science and mathematics. But this is what too often is lacking.

A remedy for the ills which Dr. Waddell brings before us is frequently suggested in the raising of entrance requirements—this is one of Dr. Waddell's minor suggestions.

But we have already raised our requirements until the preparatory schools can not efficiently meet them.

The boys who graduate creditably from good preparatory and high schools are frequently unable to pass our entrance examinations; examinations, by the way, which we should continue to insist upon.

In other cases, when they do pass, they later fail when they are required to *use* in their advanced work the subjects in which they have passed satisfactorily for entrance.

The demand made by us in our entrance requirements and the natural ambition of the primary-, grammar-, and high-school teachers to raise the standard of their

work has not generally resulted, in my opinion, in the better equipment of our boys and girls for their life's work. Thoroughness and power to do has been sacrificed to a wrong conception of breadth. The introduction of fads has resulted in superficiality.

There is a limit to the powers of absorption of the young mind, and I believe that in our elementary schools we have reached and passed the limit.

I, for one, would be in favor of the schools and colleges coöperating to reduce these requirements provided we could thus secure students better grounded in the more elementary studies; better able to use with facility and accuracy the parts of arithmetic which will be always required in their studies and their life's work; better prepared especially in English, and with that great advantage to be derived from the consciousness of power to do *well* that which is required of them.

Nothing in the way of so-called higher education can compensate for the lack of thoroughness which I believe to be a marked feature in the results now generally obtained in the educational institutions in this country.

I advise those professors in our technical schools, who have not yet done so, to test their students of the *higher* classes in the fundamental work required for admission. I do not mean the things that they were required to memorize so as to pass entrance examinations, such as facts of history, rules of rhetoric and the like, but say questions in proportion and percentage; questions in elementary mechanics; questions in geometry, algebra and trigonometry, not directly in the line

of their present work, but still elementary in character and needed for the work ahead.

I am afraid they will find that the very processes which the students should not only know but be able to operate in with facility, as a mechanic works with his tools, have been forgotten. And the failure of these students is due to two reasons:

First, they never have been thoroughly trained, owing to the crowding of the courses in the schools;

Second, what they have thus partially learned has often been crowded out or blurred over, due to the crowding of the college course. In both school and college they have been so hurried from subject to subject that they have been unable to get that grasp of any subject which only comes from the opportunity to rest on it and apply it.

Understand, I am not speaking of the weak men, the men who would necessarily be weeded out in attempting an extra heavy course, such as some of us are responsible for, but I am speaking of what often happens in the case of men of better than average ability.

Now let us bear in mind, that no matter what the progress in science and engineering, it will take four years of honest work in our best engineering colleges to prepare our men to properly appreciate the progress in these departments. The theories included in our elementary work have to be amended from time to time, but this does not add to the burdens of the course—these are only substitutions. So with some of the later developments due to research work in science and engineering—these can frequently be brought forward as illustrations and applications of principles in place of

other illustrations and applications which can be eliminated wholly or in part.

But no matter what we may thus do in the way of substitutes, we can not reasonably expect to turn out thoroughly trained engineers in four years, or five years, or six years, or seven years.

Independent of the question of the time to be devoted to undergraduate work, there is something the student must get outside of the college walls. He has much to learn through actual experience in the world of work. He must through experience learn to *do*.

Extend the time which the student is to spend in undergraduate work and you are increasing the chances of his refusing to acknowledge the need of experience-learning. There is a distinct danger in keeping him too long within the college walls.

Most of the best post-graduate work is done in connection with wage-earning, though I do not question that immense good can be done by the development of post-graduate courses in engineering, provided they are wisely conceived and administered and especially do not develop along too academic lines.

In the regular four years undergraduate course perhaps some little specializing within the field of engineering can be done to advantage, but the chief care should be to cover thoroughly those studies, general and technical, which any and all engineers need as a foundation before they commence to specialize.

But every engineering course should include a more or less extended course in the application of electricity, complete as far as it goes. This is a branch which no

engineer-student can now afford to neglect, no matter what his specialty is to be.

Dr. Waddell suggests as a further remedy for the present incompleteness of engineering courses of study:

(a) Raising the requirements for entrance, especially in English;

(b) Throwing back on the preparatory school a large portion of the present work of the freshman year;

(c) Omitting unnecessary studies from the curriculum, mostly foreign languages;

(d) Increasing the length of the working-year, say to eleven months.

Items (a) and (b) may well be considered together, for if we are to throw part of the work of the freshman year back on the preparatory school, we must again raise our entrance requirements, and this, as already said, has been already carried to a dangerous extreme.

(c) If we are to cut out any of our present studies, we are in danger of making our courses too narrow and too technical. I certainly do not think we can afford to cut out entirely foreign languages. Agreeing, as I do thoroughly, with Dr. Waddell as to the importance of more complete training in the mother tongue, I should not care to deprive our students of the opportunity to study their mother tongue from the other point of view afforded by the study of a foreign language, nor should I like to deprive them of the opportunity thus afforded to obtain a broader culture.

(d) If we at "Stevens" should attempt to gain time by increasing the working year to eleven months we should be forced to cut out some of the work done in

the nine months now included in the working-year, for the men, or the majority of them, require a long vacation for recuperation. Men of exceptional mental and physical strength can cover some additional work during the long vacation, but it is fair to those who are willing to work hard but who are not rapid in acquiring knowledge to allow time for them to catch up and let the nine months' acquisitions soak in before reaching out for more.

If two of the three months of the long vacation were to be devoted to engineering study, it should be exclusively in the line of practice—not in adding to the store of knowledge.

With our curricula crowded as they now are, we must above all things be careful not to crowd them still more.

But in many cases, I believe, some time can be gained by better coördinating and harmonizing the several parts of the course. At present there is in many colleges too much independent work by the several departments. No one department should be allowed to add to or change its requirements without full consideration of the course as a whole. The work of each department should be made to reënforce the work of every other department.

Especially should every effort be made to discourage the neglect of the more general studies that more attention may be given to the more technical subjects. Especially should the study of English be protected from such invasion. The natural inclination of a majority of engineering students is to regard the general studies, English especially, as of minor importance, with the natural result that when students find it difficult to

cover the whole course they take on conditions in English and other general subjects, and finally remove these conditions on the lowest possible passing-marks.

This is one of the most narrowing features of the work in engineering colleges and should be sternly repressed. At "Stevens" we permit no such discrimination against the more general studies, and especially English, the study of which is not completed until the thesis has been accepted by the department of English.

Dr. Waddell's final suggested remedy is the establishment of a post-graduate school of *civil* engineering. I hope he intended to say a post-graduate school of engineering.

Here is a line along which good work can be done, though I believe it should not immediately follow the undergraduate work.

By the time a young fellow has taken his first engineering degree he will probably be about twenty-two years of age. At "Stevens" the graduates average something more than this. At this age it is high time he was getting out into the world to earn his living and learn those lessons which can only be learned from his experiences in the world as a bread-winner.

The time is coming, yes, it has come, when we can not expect to train engineer-students for all branches of the engineering profession. Engineers must *closely* specialize. This does not mean that the engineer-specialist should not have a good general command of engineering subjects, but he can not well expect to know more than one branch in all its details, technical and commercial, so as to be a thoroughly competent adviser in that one branch.

Our engineer-students should have pressed upon them all through their course that during the four years they are only preparing for their real engineering work and that after graduation it will remain for them to acquaint themselves thoroughly with the technical and commercial details of some one branch of engineering work. And especially should it be impressed upon them during their student days that the engineer must be able *to do* as well as *to think*; that he must be able to apply efficiently and economically his engineering training so as to obtain for himself or his employer the greatest possible return upon the least possible investment of capital, and to this end he must be an efficient man of business as well as an engineer.

If within the four years, the students are given the benefit of a well-balanced course, thorough in fundamentals, broad in its scope, and placed before them through efficient methods and efficient instructors, the majority of the students can get their post-graduate courses out in the engineering world while earning their bread and butter. It will remain then for the exceptional few, first to take advantage of the post-graduate courses of the college and later introduce the higher knowledge so gained into the field of practice, first for the benefit of themselves, and second for the benefit of their fellow-workmen less favored or less fully endowed.

It would be useless to attempt to prepare our educational institutions for turning out only completely educated engineers. There will continue to be, as there have been always in the past, exceptional men who will go to the front and who will prepare themselves in spite of all obstacles to fill the more important positions.

But Dr. Waddell is unquestionably right in urging the advantages of a great post-graduate school of engineering which can afford greater facilities for advanced learning in engineering.

There have been some notable advances already made in this direction and there is no good reason to think that the institutions already developing post-graduate courses will not be able to meet the developing requirements.

If advanced degrees are to be granted by these institutions, then certainly every care should be taken that they are not granted except on complete evidence of ability to direct advanced work. Especially should the danger be guarded against of granting diplomas for mere attendance on "broadening" lectures.

If a thorough system of post-graduate engineering instruction could be developed in this country, then many of our engineering schools could well afford to confine their four years courses to work in general engineering, leaving the specializing to come later, either in actual practice, for the majority, or in post-graduate work for the more favored few.

Unquestionably, four years can be used to advantage on such general engineering work. Nor would this to any great extent make the majority of our graduates less capable as wage-earners immediately after graduation. In studying such questions I naturally go to the record furnished by the directory of our alumni. There I find that although we differentiate slightly in favor of the mechanical side of engineering, our men are occupying positions of importance in all branches of the engineering profession.

DISCUSSION.

THE PRESIDENT: Dr. Humphreys has until recently been a practitioner, and he has been, for a limited time, an educator. In asking for a paper from Dr. Humphreys it seems to me it would be very valuable to this Society to have a paper from a man whose standpoint would be largely that of the practitioner. To me it is very interesting to see what the practitioner in close and immediate contact with education does have to say, and to note how little he differs from many of us who have acquired the standpoint of the educator rather than the practitioner. I hope this very able paper will be discussed.

PROFESSOR JOHNSON: In line with the remarks of the President with regard to the point of view of the practitioner, I think the practitioner and the educator are nearer in line than we sometimes imagine. I once had a conversation with a superior of mine who, at the time I was in his employ, was superintendent of a rolling mill plant. He had had very little school instruction, but was a man of keen intelligence, and he had pretty good ideas in science generally. I met him ten years after I had been in his employ, and finding out that I was a teacher of engineering, he unburdened himself a little. He at that time was superintendent of one of the largest steel concerns in Pittsburg. He said to me (and he spoke as if from a deep sense of conviction): "The trouble with engineering graduates is not that they are too theoretical, but they are not theoretical enough." He meant they did not know well what they might be expected to know, and that a stricter attention to fundamentals should be the burden of our effort.

I think President Humphreys might have mentioned one more thing which it is important to learn in college. That is, that one *can* and *must* learn constantly after leaving college and that too without any sort of systematic instruction from a teacher. To learn that one can learn without a teacher is a good deal of an achievement. Students do not seem to realize that engineers are constantly confronted with problems involving great responsibility, where there are no instructions at all, and where what is to be done must be learned on the spot. Students must learn that readiness to face such situations is expected of them.

PROFESSOR S. N. WILLIAMS: I have had occasion to consider the subject which has been discussed in President Humphreys' able paper, and have come to a conclusion which perhaps is not the same as held by others, and yet is quite satisfactory to myself. In our own college, the graduates are turning largely to the professions of law, medicine, and theology. After taking our college course of four years, it is necessary for the greatest success, to spend three or four years additional in post-graduate work. The tendency in medical schools, at the present time, is to exact four years' work. I think many of the law schools perhaps do not require more than three years. Theological schools require three years, in addition to the college course of four years. Their preparation then requires, after leaving the high school, seven or eight years of close hard study, before undertaking to practice. A great many of my own students are unable to finish their college course, on account of lack of means, and are turned into business of various kinds, or professional work, without

finishing. I have felt also that possibly we were not devoting sufficient attention to the study of English, although I see that condition is being greatly improved and has been commented on both in our recent reports and in addresses which have been made in the various educational organizations. I believe the tendency is perhaps to make our courses too technical. My conclusion has been that it is best for the civil engineer, after finishing the four-year course, to spend probably two years in a thorough study of some special line in some one of the great engineering schools, and I think all of them are offering decided advantages for post-graduate study, so that this is one remedy for the difficulty discussed in the paper. I would like to add as comment on another point that while many of our students, perhaps, come from a different class, those who are not so thoroughly trained, many of them having been unsatisfactory in their previous high school courses, I have found them to be largely deficient in the principles of mensuration and in the accuracy necessary at the opening of college years, so that I have had to spend some time in drilling them in plain accuracy, and in reviewing simple mensuration, such as they are supposed to have studied in the high schools. We have also found a lack of thoroughness in the mathematical training of many of the high schools, which I presume is not the case in the eastern states where high schools and secondary schools are generally very thorough in their work, and are obliged to correct this defect before allowing them to continue the college mathematics.

PROFESSOR C. M. WOODWARD: This brings up what we

have often discussed—the reason for the crowding of the curriculum.

It seems to me we are all more or less guilty of unconscious work in that direction. As engineering has been differentiated again and again, and as each branch has added a professor, who has in his enthusiasm for his own department very naturally insisted on building up his department thoroughly and fully, the common work and the fundamental work has been driven into a corner. They have driven away mathematics, which underlies all; they have driven away mechanics, and language culture, until it is largely an attempt to dispose of all such things during the freshman year. That is the tendency which has risen very naturally and very logically, in consequence of the increase in the number of subjects each professor sees in his own department.

We are embarrassed by the wealth of text-books in engineering. Here is a magnificent book that teaches a single point in a single branch of engineering. It is so good that the subject must be introduced, and find a place in the program. It has been my fortune as dean of a school of engineering to take the requests from all the different professors in the different departments, and work out a program in which the student shall not be overloaded, and in which everything shall have its share of attention. The curriculum has been crowded, with the result that the fundamental work—the common work—has been slighted.

The last remark in that paper of President Humphreys' was very suggestive, that although his students graduate largely as mechanical engineers, yet in actual

practice they find occupation in all branches of engineering. That ought always to be so. The student ought to be able, when he takes a degree in one branch, to read and learn by himself. As Professor Johnson says, he must be able to teach himself, and he can only learn to do that by being absolutely strong in the fundamental parts of engineering. We can not anticipate professional life in the school. A lot of economics in the line of engineering is not worth while in a school. One can learn that best when he goes out to work under other engineers. In the school he has to learn the fundamental laws and processes that never change.

I remember a young man once came into my class with his fist doubled up very much as if he were going to attack me, and he said, "I believe I can read Rankine." I said, "If you can read Rankine you don't need me, because you can read anything." One of our electrical engineers was employed as an electrical engineer for a street railway company, and the manager of the road, who had failed to see the distinctions between the various branches of engineering, said to him one night: "I want you to put in new curves on our tracks at every street corner." He had never read anything about railway curves and switches. It was not in his line of engineering. But he said, "Very well, I will do it." He bought a book and sat up nights and studied until he mastered the subject. He put in the curves so well that the manager was satisfied and came to the conclusion that the young man had spent his time during his undergraduate course studying railway curves. That is what every engineer ought to be able to do. I think there is no valid excuse for overcrowd-

ing the curriculum. Excessive differentiation should be avoided.

PROFESSOR JACOBY: So far as the subject has been discussed in our faculty, not a single voice has been raised in favor of reducing the work in mechanics in order to make room for other subjects, as every one recognizes the dependence upon it of the subsequent technical courses. To reduce the quality of the work in mechanics is to reduce the efficiency of the other courses.

It is an open question, however, whether in the mathematical courses the quality of the work may not be improved by slightly reducing its range. May not some topics now included be studied to better advantage in connection with the student's practice after leaving college? In our college of civil engineering the curriculum seems to be crowded to the limit and if any other subject is to be introduced something must first be taken out of the course.

PROFESSOR TURNEAURE: One way to avoid crowding of the curriculum is to permit a certain amount of specialization; and I am of the opinion that some concentration, such as is permitted by a reasonable amount of specialization, is to be preferred to a curriculum in which an attempt is made to cover a wide field by the insertion of a large number of short courses.

In the civil engineering course, as proposed by the committee, there were, as I recall it, several short courses of two hours each for half a year. Such courses, it seems to me, must be considered largely as information courses and of comparatively little value as training courses. Instead of including so many short

courses, is it not preferable to specialize to a certain extent, permitting the student to continue in the work in which his chief interest lies? As the laboratories in our engineering schools become better developed and opportunities are offered for research work, it seems to me that it may often be desirable to spend more time on particular subjects preparatory to research work for those students who are capable of carrying on such work. To some students research work is very valuable, and it tends also to promote enthusiasm throughout the entire college.

The remarks of President Humphreys about what the employer wants in a technical graduate are borne out by my own experience with employers of our students. The employer of large experience is certainly not looking for a man who is at the outset an engineer or who is specially trained to do a particular thing. He wants a man thoroughly trained in the fundamentals. As a chemist in a large manufacturing establishment expressed it to me a short time ago: "We do not want a man who knows all about our special work; we can teach him that. But we do want a man with thorough understanding of chemistry and who has the ability to solve problems in chemistry." I think the employer and the educator are not very far apart on this question, less so, perhaps, than would appear from the papers and comments that appear from time to time. I am not in favor of specialization for the purpose of fitting students in some narrow line of engineering practice, but I do favor a certain amount of concentration, particularly for our best students in order that they may come in touch with problems similar to those which arise in

practice, the solution of which has been fully worked out. I dare say that few educators who are giving advanced courses in engineering are expecting to prepare their students to be specialists in that branch of engineering. Such a view of specialization is narrow and tends to make such work unprofitable.

THE EXTENSION OF ENGINEERING INVESTIGATIONAL WORK BY ENGINEERING SCHOOLS.

BY ARTHUR N. TALBOT,
Professor of Municipal and Sanitary Engineering, University of Illinois.

The growth of the engineering school in the United States during the past decade has been wonderful—number of students, equipment of laboratories, facilities for instruction, and systemization of methods show great changes. During the same time, methods of engineering construction and details of practice have been modified in a marked degree. Engineering science has been undergoing a very great development; but this very development has widened its field, deepened the requirements, and intensified the need for investigation and experimentation. Engineering art must rest on engineering science, and engineering science is yet in its infancy. The future development of engineering depends in a considerable measure upon the development of engineering science. Individuals and corporations are doing more toward this development than ever before. It is the purpose of this paper to raise the question whether engineering schools are doing all they may to extend engineering knowledge and whether it is not their duty more actively to undertake research work.

It may be well to call attention here to the advances made in the field of agricultural science in the past fifteen years. We are apt to think of the improvements made in the engineering side of agriculture as the one

change in the farmer's life, but the work accomplished by the state agricultural experiment stations since the passage of the Hatch act in 1887 is not generally appreciated. With trained investigators, protracted and systematic experimentation, coördination of work, coöperation of stations, and effectiveness of methods these stations have been enabled to contribute more to the science of agriculture than had been added in a hundred years before—until at last there may be said to be a science of agriculture. The national government gives well up to a million dollars annually in support of this work. The state of Illinois is giving \$85,000 annually for investigational work in agricultural science, making, with the government appropriation, over \$100,000 for experimentation in this one state. It is altogether too soon to make an estimate of the good accomplished by these stations, but the results are many and wide. The work done in determining the conditions necessary for transmitting nitrogen from the air to the soil by aid of leguminous crops is of inestimable value in perpetuating the fertility of the soil. The modification of the content of the corn kernel, the preservation of fruit, protection of trees and crops from destruction or injury by pests and blight, and even matters extending into what may be called the manufacturing and commercial side of agriculture, attest the importance of these investigations. Nor does the usefulness of the station appear to grow less; rather does each discovery open up a broader field and show the need for deeper research.

Engineering science is for the most part comparatively new and much of it is still crude. Some of the

older branches of engineering still depend more or less on rule of thumb. The newer lines, like electricity, have benefited from general scientific research and the fund of knowledge is growing. Manufacturers, railroads, municipalities, and engineers are constantly adding to engineering knowledge. And yet there is need for the extension of experimentation, and engineering schools may well take up this work more vigorously.

Experimental work in connection with engineering schools may be of three kinds: (1) Regular class laboratory work so directed and so modified from year to year that the collective data will give considerable information along certain lines; (2) special investigation made by students as thesis work or other than class work; and (3) research work by skilled investigators made not for instructional purposes. The field for the first is not broad, but it may be carried on in such a way as not to injure the instruction, since it may be done as a regular class exercise. The second has larger possibilities and is already productive of valuable results. The third must be the main source of research work of magnitude and importance. Experimental work on the larger problems must be protracted and continuous and made under uniform conditions. As illustrations of work in which a continuation over a considerable time has aided in giving results, locomotive tests and timber tests may be cited. Altogether a large number of valuable contributions to engineering knowledge have been made by engineering schools.

Granted that the principal function of an engineering school is to give instruction, it does not follow that in-

vestigations carried on by students in the manner above described are not advantageous to the student, and surely the presence of research work carried on by skilled investigators will furnish stimulus and inspire ambition in the student. With the development of engineering interests must come a growth in special research work if engineering is to keep up its pace. Engineering schools feel the importance of this and generally are enlarging the scope of the work they are undertaking.

For example, the University of Illinois has established a state engineering experiment station. Iowa State College is planning considerable experimental work in the same way. A considerable number of institutions are planning work on a larger scale than has heretofore been possible. Surely the opportunity and needs of research in engineering are not less than those in agricultural science. And the need for the engineering experiment station is as great as it was for the agricultural experiment station.

If the importance of engineering research be conceded, ways and means for its advancement are fit subjects for discussion. Much of the work done in the past in engineering schools has not been available to the engineering profession. It has not been published. It has been fragmentary. It has not been continuous nor has it been completed. Its conditions have not been uniform and comparisons have not been permissible. The time of professors has not permitted the digestion of results. At least, much of the work has been subject to these limitations.

Research work, to reach its best results, when done

by a number of institutions, needs division of problems and coöperation by several laboratories, continuation of work over a considerable period of time, and publication of results and conclusions. Lack of publicity results in work being duplicated without advantage. A division of problems would enable different phases of an investigation to be taken up by individuals who would not have the opportunities nor facilities to make a complete investigation, and coöperation would permit of uniformity of methods and make results comparable and effective. The publication of results may easily be attained when work warrants it. The administrative officers of our schools may not fully appreciate the value of research work, and it is the duty of engineering teachers to present the needs and the value of this work, so that adequate funds may be provided.

To successfully get coöperation in engineering investigation by engineering schools is not an easy matter. To divide the work and correlate it and to collate and compare results would involve supervision and direction. It has been suggested that a committee of this Society might be created to have general oversight of such investigation as might be taken up and to make suggestions and stimulate interest, but the functions of the Society are deliberative and not administrative. It may be that such a committee could offer a method which would lead to the organization of coöperation in certain lines of work by institutions or groups of institutions and that the method would be productive of results. To illustrate, a joint committee of the American Society of Civil Engineers, the Society for Testing Materials, the American Railway Engi-

neering and Maintenance of Way Association, and the Association of American Portland Cement Manufacturers is considering the conduct of extensive experiments on reinforced concrete and it is expected that this will be done through the coöperation of various technical schools; the committee to furnish the materials and a part of the expenses of the tests. Other associations have utilized the laboratories of our engineering schools for research work. May it not be possible greatly to extend the usefulness of the laboratories and to secure funds from various sources for engineering research.

If engineering science and engineering industry are so closely interrelated and the technical school is a proper place for scientific research, then it is the duty of the members of this Society to make every effort to encourage engineering investigation and to embrace every opportunity for the coöperation of laboratories and the correlation of experiments and in all other ways to aid in strengthening the foundation and extending the field of engineering industry. These are almost truisms. May they not become more active realities?

DISCUSSION.

PROFESSOR MARSTON: I will say that an appropriation was made by the last legislature for establishing such an engineering experiment station at the Iowa State College. The appropriation was not as large as it should have been. We have organized our station on much the same plan as the agricultural experiment sta-

tions with a director and a station staff. It was our idea that the work should not be confined exclusively to problems mainly of direct interest to engineers themselves, but should also be of benefit to what might be called the engineering industries of the state.

PROFESSOR MAGRUDER: Several years ago Professor William S. Aldrich, in a paper before this Society, advocated the support by the general government of experiment stations for engineering science to be connected with the state universities or mechanical colleges in the different states. So far as I have heard, nothing definite has been done in presenting this suggestion to Congress, or in advancing the subject.

If it is of value to the state of Illinois to spend \$100,000 in that state in studying how a yield of a few more bushels of corn can be obtained from an acre of ground, or in solving the problem of how to increase the amount of oil yielded by a kernel of corn, is it not equally important that experiments should be carried on to discover to the citizens of Illinois who use machine tools what are the best speeds, cuts and feeds to use with high speed steel in removing of metal; or, as in the case of the field culture of corn, to solve the problem experimentally of what are the best proportions to be used in the mixing of concrete? These and many other engineering problems, the mechanical and civil engineers of Chicago and Illinois, and of this whole country, would be glad to have solved. Engineers seem to have been altogether too backward in advocating their claims upon the general government as citizens.

While some people have been looking down upon the farmer as a man who kept his nose to the soil, I am of

the opinion that the farmer, with the Department of Agriculture and sixty experiment stations employed and paid to solve his problems and tell him what to do, has a decided advantage over the engineer who is performing hap-hazard experiments in the making of concrete, and over the mechanic who is forced by his ignorance to keep his nose to the grindstone. With telephone lines and rural mail deliveries at his command, the farmer no longer leads an isolated life. While he has been dirtying his hands with the soil, we engineers have been soiling our hands with the dirt and mud of the engineering works, or the oil and grease of the machine shop, and seem to be slow in claiming our rights as citizens of this republic. If a little light could be thrown on this subject from the point of view of the statesman, it would be seen whether we of the engineering science could or could not have appropriations made by the general and state governments for use in the solution of our problems which would be commensurate with the appropriations which have been made for the solution of many problems in agricultural science. It would then no longer be necessary to call on manufacturers and private citizens to supply the means with which to try to solve some of the problems of general engineering interest and of public importance, and for the material and manufacturing welfare of the country. Would it not be well for some of us to remember that our so-called "agricultural colleges" are in law and morals "agricultural and *mechanical* colleges"?

PROFESSOR A. M. GREENE: In looking over the proceedings of the national societies I think our technical schools have done much to solve certain problems, but

there is a great lack of coördination, or rather the working of one institution with another. Most of our experiments have been tried by one institution and the results accepted as facts. If we could only get our institutions to join together in these experiments, the value, I think, of the results would be enhanced greatly. As Professor Talbot suggests, if we could work together as the experiment stations do great good could be done.

PROFESSOR FORD: In this connection the following section of the Morrill bill establishing the land grant colleges is suggestive: "An annual report shall be made regarding the progress of each college, regarding improvements and experiments made, their cost and results, and such other matters, including state, industrial and economic statistics, as may be useful, one copy of which shall be transmitted by mail free by each to all other colleges of the same class, and one copy to the Secretary of the Interior." Have we not here the means of coördinating the research work of the engineering schools as has been done in the case of the agricultural schools?

INDUSTRIAL CATALOGUE LIBRARY.

BY JOHN G. D. MACK,

Professor of Machine Design, University of Wisconsin.

A collection of catalogues adapted to the immediate needs of one's particular line of work is gathered together by every professional man. As one occasionally wishes to refer to catalogues entirely without his own line of work, it occurred to the writer about six years ago that a general collection of industrial catalogues would be of value to the faculty and students of the college of engineering as well as to members of other colleges in the university.

With this general object in view the collection to be described was commenced during the winter of 1899-1900. A printed postal card was mailed to addresses taken from the technical press, stating briefly the nature of the library and requesting copies of catalogues, circulars, etc.

It was seen at once that some method of keeping a record of this correspondence was necessary. A ledger was tried and abandoned after two weeks, and recourse had to a card system, the 3×5 medium ruled library card being used.

When a postal request is sent, the correspondence card is filled as follows:

	Ame
6/21/04	AMERICAN PRESS MFG. Co.,
N. E. 6/20/04.	Alpha, N. Y.
or <i>Doe</i> .	

The characters A-m-e are for indexing. The first date is date of sending request. The second date and letters indicate the paper from which address was taken, as *National Electrician*, 6/20/04, or the person who gave the request as "Doe." This latter information requires but a moment to fill in and is sometimes convenient if a mistake has been made in address.

These correspondence cards are filed at once in a drawer so that it is possible to determine whether a request has been made for a given catalogue, and the date of the request.

The method of handling the books on arrival will be described in detail later, but for the present, in order to show the use of the correspondence cards, it will be assumed that the following material is received from the American Press Manufacturing Company; catalogue A, Punching Presses; and catalogue, B, Swaging Machinery.

These notations are made on the American Press Mfg. Co. correspondence card and opposite each the date of receiving is stamped, this date also being stamped on the two catalogues. This card now gives the complete statement of the correspondence with this company and the material received from them.

By looking over these cards at intervals, if any establishment has not responded, a second request may be sent and noted on the card, or if a reply is received that they publish no catalogue note is made of this fact.

A postal card acknowledging receipt of catalogue is also used and in the new form a blank is left for filling in a statement of the material received.

The methods above described for obtaining the cata-

logues and recording the correspondence have proven satisfactory and require a comparatively small amount of labor in proportion to the accuracy of the record obtained.

The writer naturally began the collection with catalogues relating more particularly to his own line of work, by writing to advertisers in technical journals selected for this purpose, as he would thereby be the better enabled to devise a proper system of classification and indexing than if dealing with the less familiar subjects.

Within a few weeks after sending out requests there were about twelve feet of books laid along the floor of the writer's office, and a method of arranging them for easy reference had to be devised.

The library authorities were consulted to learn whether any of the standard methods of indexing would meet the needs of the case and it appeared that their methods would not be satisfactory. Two difficulties presented themselves; one of which was mechanical, and the other due to the subject matter.

The mechanical difficulty arose from the fact that the material varied from a small single sheet to a volume of the capacity of an unabridged dictionary, making the shelving difficult, although as it developed later, this difficulty was more apparent than real.

The second difficulty was caused by the varied product of one establishment, making an ordinary classification as arranged by some authorities impossible.

One concern may build a single line of machinery, as turret lathes, while another may build or handle articles of a general and widely diversified classification, as

shown by the catalogue of a tool machinery and supply house.

In one catalogue collection known to the writer, duplicate copies of each catalogue are obtained and the pages cut out and pasted on the sheets for classification. This must result in an enormous amount of work where the collection is widely extended, besides destroying the book itself from which one obtains an impression of the establishment which issues the book, in itself a matter of value.

The following plan of shelving was decided on: The material is arranged on the shelves in alphabetical order by the names of concerns, the word "the" and the given name of an individual not being indexed. Thus, "The Northwestern Electric Co." will be under "N" and the "John Doe Co." under "D," these being the initials of the names which attach to memory in either case.

A certain portion of the material is bound in heavy board, which seems by the laws of chance to be distributed about equally throughout the collection and causes the books to stand up well on the shelves, these board-bound copies protecting the intermediate pamphlets, folders, etc.

Each piece, as already noted, is stamped with the date of receipt. It is also stamped with the library name and receives on the back edge, if thick enough, otherwise on the upper left-hand corner, a paster $7/8 \times 1\ 1/8$ " on which is written the index name and series letter or number if the establishment issues more than one catalogue, as,

Northwestern.

A

The books which are thick enough to have this paster on the back edge are rather uniformly distributed through the collection, and thus give a clue to location with no real necessity for letters on the shelves, thus allowing the collection to always be in close formation, without the necessity for changing letters from shelf to shelf or compartment to compartment when expansion takes place. Heavy manila envelopes without flaps should be provided to hold the sheets, folders, etc., which will not stand on edge, and the envelopes should have the indexing label on upper left-hand corner.

If the person consulting the library knows the name of the concern whose catalogue he wishes to consult, the book can be found by going directly to the shelves without recourse to the index.

If, however, one wishes to look up a complete line, or some article of which he does not know the name of the manufacturer or dealer, the subject matter index must be consulted.

In the periodical and technical society literature of recent years have appeared many articles on indexing and filing catalogues, clippings, etc. One of the most complete systems is described in *Trans. A. S. M. E.*, Vol. XIV., p. 780, by Wm. L. Chase, on an application of the Dewey Decimal System to engineering literature.

The writer preferred making his own index, rather than adopting any of the standard systems of more or less complexity.

A series of standard 3"×5" ruled library cards are employed for this purpose and the classification written on the top line, and the cards filed in alphabetical order by this classification, new titles being inserted when

necessary as the collection expands. The method of indexing is as follows: The catalogues when received by the writer are placed in a desk drawer until opportunity offers to examine them, when each is turned through and has penciled on the back its index names, nothing else. This, it may be noted, is the only portion of the entire work that can not be done by a clerk.

The catalogues then pass to a clerk who copies the pencilled names on the subject matter index, stamps them and the correspondence cards, writes the catalogue name on the correspondence card as before explained, and shelves books in the proper place.

When a subject matter card is filled, the subject is continued to a second card, and so on.

If one wishes to look up an entire line of manufacturers and dealers of a given product, he examines the subject matter card and finds thereon a list of all the concerns handling it whose catalogues are in the library. With this card in hand, the separate books can readily be found, being in alphabetical order.

In order to check the books at the end of the year, one person reads the correspondence cards which show just what has been received, and a second checks the books on the shelves.

The whole system is simple and with one exception all the work is purely clerical; and at the same time the books can be readily found, when either the name or product is known. This library is used continually by the members of the senior class, and not over five minutes' explanation is required at the beginning of the year to show them its working.

This catalogue library now contains about 3,000 sep-

arate pieces and has proven of value not only to those in this college but is frequently consulted by persons connected with other departments of the university.

In the teaching of engineering the trades catalogue occupies a unique place. Many of them contain more advanced and detailed information than is given in text-books and can be used constantly in class and drafting room instruction. From them the students also learn something of prices, discounts, etc., subjects dealt with rather lightly in many text-books.

For some years the writer has used the general catalogue of large machinery supply house as a regular text-book in the sophomore machine design. Each student is supplied with a copy and assigned a certain number of pages to read over in advance.

When the class meets, the instructor discusses each article in more or less detail, describing uses, modifications, prices, etc., one of the principal objects being to give the students a course in terminology which otherwise they pick up in a haphazard manner.

To maintain this library in proper working order and up to date requires the services of a clerk on the average of about two hours per day, so that the expense of operation in proportion to results obtained is merely nominal.

For the uses of the catalogue library in general, as applied to public libraries, see article by Professor O. B. Zimmerman, University of Wisconsin, in the *Library Journal*, February, 1904, "The Collection of Industrial Catalogues by Public Libraries."

DISCUSSION.

THE PRESIDENT: There is one point which suggests itself to me in connection with this paper. It, of course, is suitable that this Society should consider the adjuncts which make teaching possible in the best way, and a paper like this is useful in that view. I believe that it is valuable beyond that; I am inclined to believe that in engineering education, if it can be done without the expenditure of too much effort, it is wise that we should secure facilities for teaching the students in methods of carrying on engineering work after graduation, and the use of proper cataloguing devices ought to be of value. The opportunity for the student to see schemes of that sort in successful use ought to be valuable to the student, as really a part of his education. So that the paper, I think, is valuable to us, not merely as aid to us in doing good work, but also valuable as part of the real work of engineering education, educating the student on one side, and apparently with very little incidental loss of the time of the student.

PROFESSOR FLATHER: I think the possession of such a catalogue system is certainly essential to the prosecution of certain lines of work, especially in machine design, in connection with mechanical engineering. I have had such a system in operation for a number of years, details varying somewhat from those suggested by the author of this paper, but, in general, conforming with the plan as presented. I have had considerable difficulty in inducing manufacturers to respond to a printed inquiry—just what the percentage is I do not know—but a large number of the printed slips sent out

are thrown into the waste basket. But if I send a personal letter, I not only get all the publications of the concern, but it is a rare thing if the travelling agent does not come and try to sell me something. I suppose that is human nature, but it is certainly a lack of good judgment on the part of manufacturers that they do not size up the advantages of having their catalogues in possession of the technical schools. This feature has been the subject of considerable complaint recently. Writers in the *American Machinist* a few months ago were decrying the same thing of not giving information where it was desired, or where no direct return was seen; and on the other hand, sending letter after letter, and even sending agents, trying to induce the writers of the original letter to purchase one of their machines. Another feature, which Professor Mack does not seem to have so much difficulty with, and which certainly has bothered me somewhat, has been the varying sizes of these publications, being anywhere from the size of a postal card to a quarto. A standard size 6×9 is now being employed by a great many firms, but I think that we, as educators, have still some work to do in educating the manufacturer, by showing him that he could save money by using standard sizes of catalogues. In the system which I have found very satisfactory, I do not arrange the catalogues alphabetically, but rather in subjects, placing them in cases. Where the manufacturer has a number of goods, I use a cross reference card catalogue system. The arrangement works well with us, and requires as little work on the part of the collector of catalogues as any system I know of.

MR. W. M. CAMP: I think that engineers fully appreciate the value of information, in various lines, that is contained in trade catalogues. An arrangement which I have found convenient for filing this class of literature is to group a number of catalogues of approximately the same size together. Those which are bound in paper I collect between board covers which have eyelet holes near one of the edges. Holes are punched through the pamphlets and then the volume of these and the board covers are tied through and through with shoe string. In this way they can be kept clean, and the covers or title pages do not curl up or become torn, as they do when they are handled separately and frequently. Later editions of the same catalogues can be inserted between the same covers. Some of the manufacturers have lately taken to the practice of issuing their catalogues and other literature sectionally. Where this is the case the different sections sent out are trimmed to uniform size, with the intention of binding them together by some ready method such as I have described. Circulars, folders, clippings and other matter of only one or a few pages each I have been in the habit of filing in large manilla envelopes of uniform size. For convenience of card indexing, these envelopes, like the file covers or binders, are numbered.

The most important thing about the filing of all such matter is the card index. Professor Mack calls attention to the inconvenience or obscurity which arises from one person writing index cards to be used by others. I think that all of us who have had occasion to use libraries much have been struck by the force of

that point. Quite frequently a book or a catalogue contains valuable information which is not suggested by the title; and then, too, it may happen that the title itself is not cross-indexed a sufficient number of times to serve the mental habits of the different persons who will be likely to seek the information. This means that those who write the index cards should proceed with deliberation, examining each book or pamphlet thoroughly and making record of all important text matter, illustrations, tabulations, etc., which might escape attention if only such general subjects as are mentioned on the title page, in the preface, or in the table of contents be observed.

In some otherwise well-organized libraries much technical literature lies unused or but seldom consulted because the indexing is too superficial. It is hardly possible for any person not familiar with the matter covered by a book of considerable scope to index that book thoroughly enough for those for whose particular benefit the author intended it. Now a way to overcome such a deficiency is for librarians to request persons who use the books to make contributions of titles for cards, occasionally, when important information is discovered that is not recorded in the index. For this purpose blank slips might be made available to be filled out by readers for the advice of librarians in regard to needed accessions to the card index. By such a means of reference to particular parts of the text the librarian can have the proper card or cards made out in accordance with the system of indexing in vogue. It frequently happens that one will discover what he is looking for by accident, or by a tedious random search

through a stack of books, in spite of the absence of any trace of the matter in the card index. If he could then be permitted to suggest titles for a few index cards he might materially improve the means of reference of the library, and thus render valuable assistance to others who will later be following the same trail for information. A simple way to encourage the assistance of readers toward making the card index as complete as possible would be to paste a small printed note inside the front cover of books, inviting coöperation whenever a deficiency in indexing is seen to exist.

PROFESSOR S. N. WILLIAMS: What arrangement have you for the use of the catalogue in the recitation room or in connection with certain lectures?

PROFESSOR MACK: We have considered the locating of this catalogue library in the reading room of the engineering building under charge of the reading room attendant.

In this reading room are the current technical periodicals and duplicate copies of many of the engineering works belonging to the general university library which is in a separate building.

The catalogue library is now located in a room adjoining my office, and is open to the faculty and members of the senior class.

The seniors take out books for use in drafting and class rooms, leaving a card receipt. Although a large number of books are out all the time, in checking at the end of the year we find the losses practically nil.

Referring to the remarks of Professor Flather, I have read the articles in the *American Machinist* regarding standard catalogue sizes, and before collecting this

library, was concerned about the lack of uniformity. Since the library has been in operation, however, I think we have scarcely given the matter a thought.

The thick books at intervals and thin vertical wooden pieces permanently fixed to the shelves serve to hold the book upright. We intend to provide a manilla envelope without flap for the thin folders.

PROFESSOR JACOBY: What is the height?

PROFESSOR MACK: Simply the height required for the larger books, about eleven inches. Occasionally there is a very large book, but these are few in number. They are placed in a cupboard and a card stating location is filed where the book should be on the shelf.

Professor Flather spoke of the manufacturers not responding. I have no record of the proportion who do not respond but believe it to be very small. It is not without value as a permanent means of advertising, as a considerable amount of material is purchased from its books, and nearly all manufacturers and dealers now recognize that the engineering student of the present day may be the man who uses and buys material in the not distant future.

I will read a postal card we send out and which is as follows:

THE UNIVERSITY OF WISCONSIN.

COLLEGE OF MECHANICS AND ENGINEERING.

MADISON, WIS.

Gentlemen: We have in this university a permanent catalogue library for the particular use of the engineering faculty and those of the other departments of the university as well as for the students and any others

who may wish to consult it. The matter is indexed and cared for by regular library methods.

Will you kindly send us the latest edition of your catalogue, illustrating all your various products, and place us on your mailing list for future editions, special circulars, etc., and greatly oblige.

Dean College Mechanics and
Engineering.

Address, J. G. D. Mack,
Madison, Wis.

WRITTEN DISCUSSION.

PROFESSOR FORREST JONES: The writer has struggled for some years with the problem of suitably indexing an industrial catalogue library, but until recently no method involving a small amount of labor with entire flexibility could be devised. "The Mechanical Index" brought out by the Industrial Publishing Co. has opened up a method, entirely satisfactory, that has been adopted by the department of machine design in Sibley College for a catalogue file used by all students in the college.

In connection with "The Mechanical Index" there is kept a card index of the trade catalogues in the college files. This card index shows the names of the concerns, nature of the catalogue, whether general, in the nature of a monograph, or containing more than one class of articles but not many, the date of issue or of receipt, the number of pages and the number of the drawer, pigeon hole or division of the vertical file in

which it is placed. The numbering system of the mechanical index is not used.

Old catalogues can be discarded and the corresponding card in the index removed. The library is thus kept up to date without growing cumbersome with old literature. As new names appear in the trade, they are added to the mechanical index. New issues of the latter can be put into use and the old ones discarded without inconvenience.

When the manufacturers of a certain article are wanted, the mechanical index is used to find their names; the card index is then used to locate the catalogue on file.

REPORT OF COMMITTEE ON REQUIREMENTS FOR GRADUATION.

Your committee appointed to report on the question, "What minimum of attainment should be considered sufficient for the first, second, etc., degrees?" submits the following:

No attempt has thus far been made to obtain opinions from teachers or practitioners touching advanced degrees. No endeavor has been made to discuss the question of what the first or other degrees should be. What has been done has been to attempt to discover the ideas of teachers and practitioners of engineering, as to what ground a young man should cover to entitle him to a first collegiate degree expressive of scholastic training in engineering science.

To this end a blank form was devised and sent to many people, a few of whom made satisfactory returns. Doubtless most of the members of this Society are familiar with the blank. It was far from perfect, and was doubtless unsatisfactory to many, who did not approve of the division and subdivision of subjects. Nevertheless a study of the replies has been of much interest, and it is hoped that this résumé will be both interesting and suggestive.

No blanks were sent to practitioners in mechanical, electrical, or mining engineering, or architecture, for the reason that at the time these were about to be forwarded; they were spoiled by water used on the fire which destroyed the main building of the Rensselaer Polytechnic Institute. Blanks had been previously

sent to many members of the American Society of Civil Engineers. Membership lists of the other societies were received later.

The blanks contained a list of general subjects and subdivisions intended to be sufficiently detailed and inclusive to furnish a good basis for an expression of opinion, and an effort was made to reduce the work of such expression to a minimum. One fact came out strongly, namely: There was an almost unanimous opposition to specialization, more evident in replies from practitioners than in those from teachers. That is, the modern division of civil, mechanical, electrical, mining and chemical engineering, architecture and naval architecture, are recognized; but no specialization by the undergraduate in such subdivisions as structural engineering, sanitary engineering, railway engineering, etc., is deemed wise.

For this reason, and because very few replies subdivided the seven general departments of engineering, only the general courses are considered in this report.

Among the practicing engineers replying are included some of the best known American names in the various branches of the profession, and their opinions are worthy of consideration. These men of long years of experience indicate by their replies that the undergraduate course shall include a thorough grounding in the principles underlying all engineering, and, so far as practicable, the details of practice of one of the seven general branches named above. This must be taken to indicate what they themselves have found use for, because most of them have outlined courses that can not be given in the usual four years, Dr. Waddell, who is

an experienced teacher, as well as practitioner, frankly admitting this impossibility. There is a noticeable demand from men in practice for a speaking knowledge of Spanish, rather for its business value than its richness in engineering literature. The number of mining instructors (3) replying on the blank is so small as to make the exhibit in this branch of less value than could be wished, particularly as the opinions on many questions are divided.

It is also evident, from the replies, that many teachers have made their opinions coincide with what they believe it to be practicable to give in four college years of present common length, varying from thirty-three to forty-five weeks of actual class-room or field work. Many instructors have evidently replied in accordance with the courses given in their own schools. Perhaps this was to have been expected from those who think they have just the right thing, but as courses are usually to some extent based on a compromise among departments, it was hoped that each reply would indicate a carefully considered individual opinion of what ought to be, rather than a statement of what is.

From the practitioners this opinion was obtained, and the committee attaches much weight to these replies. From some instructors came just the sort of replies that were wanted, Professor Spalding, for instance, noting that his reply indicated his opinion, which was somewhat at variance with his practice. The replies received indicate that a majority favor courses about as follows:

FOR ALL BRANCHES OF ENGINEERING. (Except chemical engineering and architecture.)

English.—Thorough work in correct expression, extending throughout the school course.

Foreign Language.—A reading knowledge of both French and German, or of one of these only, opinions nearly equally divided.

Mathematics.—A thorough working knowledge of all branches up to and including integral calculus.

Mechanics.—A thorough course in theoretical mechanics, including the laws of bodies in motion and at rest.

Physics.—A thorough course in all departments of physics, including mathematical thermodynamics and electrodynamics.

Chemistry.—Theoretical inorganic chemistry, qualitative analysis.

Drawing.—Thorough courses in descriptive geometry, general projection drawing, machine parts, etc., and freehand drawing.

Materials of Engineering.—Mathematics, physics, and preservation of materials.

Statistical Structures.—Courses varying with the branch to be followed. A full course with design for C.E. students, and a brief course without design for others.

Machine Design.—Course varying with the branch to be followed. Note that a majority of civil engineering instructors would omit this, while a majority of practitioners would include it.

Power.—General theory of water motors, heat and gas-engines, steam-engines and boilers and electric generators and motors, steam-engine indicator, fuel, boiler, and engine efficiency tests.

Surveying.—The theory of land surveys and leveling, with a strong minority favoring practice in both.

Electrical Engineering.—Practice followed in the generation, distribution and commercial use of electric power—a general descriptive course.

Miscellaneous.—Political economy, commercial and contract law.

Shop work is considered advisable for all but civil engineering students, and for these it is in favor with a strong minority.

In addition to these subjects to be covered by students pursuing any of the four principal branches of engineering, the following subjects should, according to the majority of replies, be covered as indicated:

Subject.	Civil.	Mechanical.	Electrical.	Mining.
Mathematics.	Probability and least squares.	Differential equations.	Differential equations.	
Chemistry.	Blow pipe analysis.	Quantitative analysis.		Blow pipe analysis. Quantitative analysis. Assaying.
Astronomy.	Descriptive. Practical, latitude, longitude and time.			Practical, latitude, longitude and time. Full course.
Mineralogy.	Descriptive and determinative.			
Geology.	Equivalent of Dana or Le Conte.			Equivalent of Dana or Le Conte. Field work.
Biology.	Water borne pathological germs, lectures.			
Drawing.	Shades, shadows and perspective. Topographical.	Shades, shadows and perspective.	Shades, shadows and perspective.	
Power.		Complete full courses, general and detail, covering water, heat, gas, steam	Complete courses general and detail, covering electric power, gen-	Topographical. General specifications for water, heat, gas and steam engines.

Subject.	Civil.	Mechanical.	Electrical.	Mining.
		and electric power generators and motors. ' Theory and use of dynamometers.	erators and motors only. Theory and use of dynamometers.	
Surveying, plane.	Complete course in plane surveying, including rail-waysurveying, and except mine surveying.			Complete course in plane surveying, including mine surveying and railway surveying.
Surveying, geodetic.	Base line, with practice. Triangulation, with practice. Figure of the earth. Adjustment of observations, with practice. Computation L. M. Z., theory. Map projection, with practice. Trigonometric and precise leveling, with practice.			
Railroad en- gineering.	Principles of location. Structures. Construction methods. Water supply. Signals — interlocking. Maintenance of way. Transportation.			
Highway en- gineering.	Country roads and city streets.			
Hydraulic en- gineering.	Water supply for domestic use. Irrigation. Power. Sewerage. House drainage. Rivers and har- bors. Canals.			Water supply for power.

Subject.	Civil.	Mechanical.	Electrical.	Mining.
Mechanical Engineering.		Heating, ventilating, refrigerating, iron and steel working. Pumping. Important manufacturing processes.		Pumping.
Electrical engineering.			Transmission line. Telegraph, telephone, lighting, electric railways, electro-chemistry.	Electro-chemistry.
Mining engineering.				Full course in occurrence of ores, methods of mining, reduction and dressing, machinery, design of surface plant, operation, management and mining jurisprudence.
Miscellaneous.	Elementary course in sanitation and hygiene, personal and social, including elementary discussion of pathogenic germs, and bacterial diseases, and precautions which may be taken.			Elementary course in sanitation and hygiene, personal and social, including elementary discussion of pathogenic germs, and bacterial diseases, and precautions which may be taken.

Not all instructors reported the time that should be given, but those who did report show widely differing ideas. Although in general the suggestions of total hours to be required for the first degree vary from about 6,600 to 8,100, the actual limits are from 5,808 to

38,540. It is considered doubtful if more than fifty-four hours per week of actual work should be required of any student. On this basis the lowest limit means four school years of twenty-seven weeks' actual work each, or, with the usual holidays and opening and closing functions, about thirty weeks. The highest limit on a basis of fifty-four hours per week, means about twenty ordinary school years, or, including the usual opening and closing functions, fourteen and one half business man's years. It is safe to say that no such result was intended, and that the excessive requirements are probably due to an error in multiplying, which would have been discovered if the author had summed the items.

It would doubtless be unprofitable to submit a detailed statement of the hours suggested by various persons for the extensive list of subjects appearing in the blank, but it will be interesting to note the hours assigned the several general subjects by representatives of the four principal engineering branches. Professor Sperr, whose figures are used under mining engineering, bases his estimate on a school year of forty-five weeks, six days in the week and ten hours a day, three years of which are equivalent to four and a half usual working school years. With considerable reason could his course be said to warrant an advanced professional or scholastic degree, and four such years would certainly warrant such degrees. The figures under civil engineering are those of Professor Merriman, those under mechanical engineering are from Messrs. Randall and Pheteplice, of Brown University, and those under electrical engineering are from Professor Sever, of Co-

Columbia University. Professor Sever's figures represent the courses given in Columbia.

Professor Sperr's figures were the only ones submitted in mining engineering, and the others have been chosen because they closely average the several estimates in their respective branches, and are nearly equal in their totals.

Subject.	Hours.			
	C. E.	Mech.	Elec.	Min.
Language	500	990	Preparatory requirement, French and German.	540
Pure mathematics.....	750	1,089	585	1,130
Theoretical mechanics.....	300	396	405	250
Physics.....	750	1,089	675	450
Chemistry	250	594	855	760
Astronomy.....	150			30
Mineralogy.....	150			350
Geology	150			540
Botany.....	50			
Biology.....	50			
Drawing	500	770	720	295
Materials of engineering ..	300	198	90	350
Statistical structures.....	1,000	66	270	200
Machines.....	150	396	180	
Power	200	1,089	1,580	210
Surveying, plane	500			765
Surveying, geodetic.....	100			170
Railroad engineering.....	300			
Highway engineering.....	150			
Hydraulic engineering.....	400			110
Mechanical engineering....	100	99	450	100
Electrical engineering.....	200		1,275	100
Chemical engineering.....	150		180	
Mining engineering.....				1,480
Architecture.....	200			
Miscellaneous.....	150	99		
Shop.....		792	180	270
	7,500	7,666	7,445	8,100

Your committee will briefly discuss two points:

(1) The *amount* of work to be performed to earn a baccalaureate degree, and (2) the *kind* of work.

Attention is called to the total figures in the table of

time requirements. These totals represent from twenty-five per cent. to thirty per cent. more time spent in scholastic work than is required by the standard colleges and universities for a bachelor's degree in arts. There was a time when a course in science, then largely a superficial, descriptive course, was considered a light course—a soft snap—to be taken only by the indolent. This is no longer true and as the figures given indicate should be the case, it is now the common understanding that a modern course in applied science is more difficult, and requires the expenditure of more time, than a course in arts. The tendency is to add rather than to subtract or stand. Your committee suggests that when the requirements for admission to arts and science courses call for essentially the same amount of preparation, the bachelor's degree should be given for essentially the same amount of advanced work; that, in short, the baccalaureate degree should represent a certain definite minimum total of scholastic work performed, whether that work be in so called arts or in science, pure or applied, with this proviso, namely: That no scholastic degree should be conferred on any one who has not mastered a certain definite minimum of language, both native and classical or modern foreign. A conclusion as to the minimum requirements will be stated hereafter.

In determining a course in applied science, this question must be asked concerning each subject considered, namely: Is the object of the study of this particular subject, culture or general education, or is it pure utilitarianism? Answered either way, a second question arises: What shall be the nature and amount of work

to be done in this subject to make it of value? Each of the general subjects enumerated on the blank may be briefly discussed.

Language is both cultural and useful, and is deemed of the utmost importance. In English the requirement should be the usual modern requirement for entrance to an arts course and not less than the equivalent of one exercise in composition each week throughout the course. This may be given in any one of several ways.

French and German, while useful, are to a greater degree a matter of general education, and a thorough reading knowledge may suffice, although a speaking knowledge is desirable. A thorough knowledge of these languages enables a man to meet other educated men with a feeling of equality, while the lack of such knowledge puts him in his own estimation on a lower plane, a most unfortunate and unhappy condition.

The close connection between the United States and Spanish-speaking countries makes Spanish a useful rather than a cultural language, and a speaking knowledge of this language is highly desirable, though not absolutely necessary. On this point an extract from a letter from Mr. Edward P. North is of interest. Mr. North says of Spanish: "It will be for one hundred years to come, convenient and necessary in all the country south of us, except where Portuguese is spoken. That country is undeveloped and presents the largest field for future employment open to American engineers."

Pure mathematical studies are tools first, and are, second, of some educational value in developing unconsciously the habit of reasoning correctly from cause to

effect; but the study of logic is of far more value in teaching the student to require full and correct premises for his conclusions; and physics and mechanics are far more potent in teaching him to always ask why, the proper question for the observer—which every engineer should be—and to be satisfied only with a reason or cause that fully explains. Therefore, mathematics will be considered simply as a tool. From this standpoint what is required is a thorough working knowledge of so much mathematics as may be of practical use. It will probably be conceded that this means for all engineers thorough courses in all higher mathematics through calculus, with the addition of a short practical course in vector analysis for electrical engineers. For men proposing to make geodesy a specialty, thorough preparation in probability and least squares is essential, but as the replies received force the committee to the ground that specialization in an undergraduate course in any of the seven principal departments here considered is unwise, such a course is not advised for any undergraduate engineering student. But it is a fact that a large percentage of engineers of all departments make occasional experiments or observations, for obtaining empirical formulas or coefficients for theoretical formulas, and it is always desirable to know the degree of precision of the results.

It is thought wise, therefore, by the committee to include in all courses a very brief practical course in the determination of probable errors of observations.

Theoretical mechanics is regarded as fundamental in all departments, except, possibly, chemical engineering. It is doubtful if too full a course can be given.

General physics again is fundamental for all engineers, and while the several subjects included under this head are of very unequal importance, they should all be taught, and much time given to the more important branches of hydrophysics, light, heat, electricity, and pneumatics. Whether thermo- and electro-dynamics be considered a part of general physics, or as belonging elsewhere in the schedule, they should both be given to all engineering students of the first four departments, while for chemical engineers, architects and naval architects the course may be a short practical course, or nothing at all.

Chemistry is more a tool than an educational subject, though theoretic chemistry is to some degree cultural. This being true, the committee thinks that the usual courses go farther than necessary or desirable for all branches of engineering except mining and chemical engineers, and possibly electrical engineers. For chemical engineers not too much is likely to be given, while for mining engineers organic chemistry may well be omitted. For all others it is believed there should be given a thorough, practical course in theoretical chemistry and a very brief course in both qualitative and quantitative analysis, made thoroughly practical by confining it to the analysis of well-known ores, natural building materials, and commercial metals and alloys, rather than to compounds cooked up in the laboratory. The course should be such as to give the student an insight only into chemical methods, without making an expert qualitative or quantitative analyst.

Descriptive astronomy is a cultural subject for all

engineers, and if studied at all, should be given but little time.

Practical astronomy, the determination of latitude, longitude, and time, is of practical use to civil and mining engineers, any who may be expected to become to any degree explorers. A somewhat thorough course in this subject, using only ordinary field instruments, should be given, and a brief course with the larger, portable observatory instruments.

Descriptive and determinative mineralogy are essential to the civil, mining, and chemical engineers, and desirable cultural subjects for all men. The other subjects listed under mineralogy are essential to mining and chemical engineers.

The ordinary course in geology is of value as a matter of general education to all educated men. The equivalent of Dana or Le Conte should be required of all engineers, and a more thorough study with field work should be required of mining students.

A knowledge of the wild flowers is a delight on a summer vacation, and is often of considerable value, but it is largely a cultural subject, and may be taken up on any summer vacation with the help of Mrs. Dana and a "Gray." But an intimate knowledge of forest trees is of the utmost value to the civil engineer, and is likely to be of great value to the mining engineer and the architect. A course that will enable the engineer to know the various trees when he sees them, their uses, and the qualities possessed by the lumber made from them, their diseases and defects, is entirely desirable for the civil engineer, and is thought by your com-

mittee to be desirable for the mining engineer, architect and naval architect.

It is thought that the chemist or chemical engineer should be familiar with laboratory methods for the biological analysis of domestic water supplies, and that the civil engineer should understand how to interpret both a chemical and biological analysis of water. To this end the civil engineering student should be given a brief lecture course in water analysis, illustrated by a few laboratory observations of the principal water-borne pathogenic germs.

Mechanical drawing, except topographical drawing, is fundamental to all branches except chemical engineering, and free-hand drawing is an essential to all, but not to the same extent. The architect must be an artist, the others simply able to express their ideas. The civil and mining engineer and architect should all thoroughly understand topographical drawing.

The mathematics of the materials of engineering is an essential tool for all except chemical engineers, and the course should be thorough. Civil and chemical engineers and architects should be familiar with the principles and methods of wood preservation.

The mathematics and the practice of statical structures are essential tools of the civil engineer and architect who is more than a decorator.

Mechanical, electrical, and mining engineers should be familiar with the general principles and methods of determining stresses in machine parts, and in foundations.

The principles of machine design should be taught to

all engineers except chemists. The subject is purely utilitarian. It is not essential to the architect.

The general principles and principal types of all power-generating machines should be familiar to civil, mechanical, electrical and mining engineers. The details of construction, design and operation of water, heat, gas and steam plants should be familiar to the mechanical engineer, and the details of electrical plants and processes to the electrical engineer.

Surveying is a tool rather than a cultural subject. The elements, theory of land surveys, leveling, and topographical surveys, are useful to the architect. The use of instruments in laying off angles, and leveling, is of use to mechanical and electrical engineers. All plane surveying is of use to civil and mining engineers.

By geodetic surveying is meant only such surveying as necessitates a consideration of the spheroidal form of the earth. Ordinary base line and triangulation work is supposed to be included under topographical surveying. With this understanding, it is thought to be unwise to give more than a course in the theory of geodetic surveys, and this only to civil engineering students.

The subject of railroad engineering, except as it includes motive power, is of interest to civil engineers only. For the undergraduate student it should include the principles governing location, form and design of minor structures, methods of construction, elementary principles, but not construction details, of signaling and interlocking, principal laws governing common carriers.

It is intended to include under principles of location about what is covered by Wellington.

Mechanical engineers should be familiar with train, grade and curve resistance, and the principles of design and method of tests of locomotive engines.

Highway engineering is of special use to the civil engineer only. The subject is largely descriptive and should be given but briefly. About what is included in Baker should be covered in from ten to fifteen exercises.

Hydraulic engineering in its entirety, except the detail design of motors, is a utilitarian subject for the civil engineer, and should be thoroughly treated. The whole of Merriman's "Hydraulics" and parts of Turneaure and Russell's or Folwell's "Water Supply," Folwell's "Sewerage," Frizell's "Water for Power," and Wilson's "Irrigation" should be covered. In addition there should be lectures or seminar work on canal construction and the improvement of rivers and harbors.

The capacity of streams for power development should be briefly treated in the mechanical, electrical, and mining courses.

The general types and the duty of pumping engines should be studied by civil and mining engineers, and all of the subjects under mechanical engineering should be well covered by the mechanical engineering students.

The general mill methods of producing structural metal should be briefly studied, say by one or two illustrated lectures and as many visits to a large mill—by civil engineering students.

All engineers except chemists should be familiar with the general principles and methods of electric power

generation and transmission, at least to the extent of the ability to use Foster's " Pocket Book " for making rough preliminary estimates of possibilities.

Chemists should be thoroughly grounded in electro-chemistry. Architects should understand the principles of house wiring. With these exceptions the entire subject of electrical engineering may be said to belong to the undergraduate electrical engineer only, who should thoroughly cover the whole list.

Under chemical engineering—a utilitarian branch—the civil engineering student should be familiar with the metallurgy of iron and steel, the analysis of cements, the methods of sewage treatment and water analysis; the mechanical engineer should know the metallurgy of iron and steel, and the electrical engineer the metallurgy of copper and aluminum, and the general subject of electro-metallurgy. With these exceptions the field belongs to the chemical engineer or chemist, who should cover it all thoroughly.

The mining engineer only is concerned with the subject of mining engineering, and the whole list of subjects given should be thoroughly taught.

As a utilitarian subject architecture seems to belong to the architect only, but the history of architecture and decorative art are of great value in general culture, and whether or not the high school student is sufficiently advanced to pursue these studies intelligently, the committee is inclined to agree with the main idea expressed by Professor Wm. Kent as follows: " You may be surprised that I have marked history of architecture, architectural forms, decorative art, as proper subjects for the high school, but I consider that these subjects have

a far higher educational value in training the eye and the reasoning powers than have such subjects as civics, physiology, New York state history and history of literature, which are now generally taught." Without wishing to argue as to the relative desirability of various culture subjects, it is thought that so much architecture as Professor Kent mentions should be covered in an elementary way by all well-educated persons. Beyond this, the subject of architecture is for the architect; but the committee feels unable to assign a minimum time limit to this subject with any degree of confidence in the value of the suggestion. Suggestions by instructors in architecture will be welcomed.

Except something of the resistance of vessels in restricted and open waterways, which may be profitably considered by the civil engineer, the subject of naval architecture is for the naval architect, who should know it thoroughly.

As a matter of general education of the good citizen it is thought that the American business man should be familiar with the elements of political economy, commercial and contract law, and physical and commercial geography.

The mechanical, electrical, and mining engineer should be fairly familiar with shop methods and more or less expert in handling shop tools, foundry, forge, and machine. To the civil engineer this is of less importance, and if not acquired in the preparatory school, the value of much time spent in actual shop work in college may be doubted.

The following extracts from letters from practicing

engineers and engineering instructors may be of interest on the question of specialization.

From Professor Wm. Kent: "I would like to go on record as being opposed to any specialization whatever during the four years' course. An engineering specialist should, before he specializes, take a complete course in one of the regular branches of engineering."

From S. Whinery, consulting civil engineer, New York City: "I did not have the advantage of a (school) technical education. I have filled the blanks, therefore, from the point of view of a non-graduate engineer, looking back and judging what seems to him now would have been of most benefit to him in the way of a course of technical study as a preparation for the professional life of a civil engineer. The general idea underlying my selection of studies is that in a four years' course of study the most that can be hoped for by the average student is a thorough mastery of principles, or, as it is usually called, theory.

"It seems to me that the present tendency in our technical schools is to attempt too much, and more than the young man can accomplish thoroughly unless his intellectual capacity be unusual."

From Octave Chanute, consulting engineer, Chicago, Past President American Society of Civil Engineers: "My general notion about technical education is that the student should be well grounded in the general principles of science, taught where to look for further information when in need of it, and instructed how to assimilate it. In other words, that he should learn the use of the tools of knowledge. I apprehend that the modern course goes too much into detail."

From John Lyle Harrington: "The new graduate is not an engineer, but he should possess a broad and firm foundation upon which to build. A narrow preparation forces him into a rut and limits the field of his activities, often to his distinct disadvantage. I do not believe the schools should turn out specialists in some particular line, but men who are fitted to become specialists in any line."

From W. W. Curtis, consulting engineer, Chicago: "In the first place, thorough grounding in principles rather than practice."

From A. H. Renshaw, New York City: "I take the ground that there is but one kind of engineer so far as the degree is concerned, who may specialize afterward in his professional career."

From F. Collingwood, consulting engineer: "I am very strong in the opinion that too much is attempted in the schools. * * * The most that can be done in the brief period of study at any college, is to get the rudiments thoroughly grounded in a student so that it becomes a second nature for him to think *rightly* at the start; to go to the *root* of the matter every time. I do not believe at all in specialization until *all* this is thoroughly done."

Your committee presents the following conclusions—not as representing the unanimous opinion of the committee, but simply that there may be definite questions for your consideration and discussion.

1. The fundamental principles underlying civil, mechanical, and electrical engineering, and naval architecture are to some degree of the natural sciences, but are essentially mathematical science, and should all be

covered by the undergraduate student in any of the four branches.

2. The fundamental principles underlying mining and chemical engineering are essentially of the natural sciences, and should all be covered by the undergraduate student in either branch.

3. Architecture is essentially a fine art, and stands by itself, requiring a limited amount of mechanical theory and a considerable amount of structural detail for its development.

4. Assuming entrance requirements of one foreign language, elementary algebra, and plane and solid geometry, the first or baccalaureate degree should be granted on the completion of a minimum of 7,200 hours of actual work of college grade. Should admittance be on a lower standard, the number of hours named is to be increased accordingly. It is understood that the hours named include preparation and class exercises, each hour of class exercise counting for three hours total, each hour of laboratory work requiring no preparation counting for one hour. The number of hours assigned is supposed to be that required by the average student; the quick man will use less time, the slow man more.

5. The proper distribution of time among the several subjects is submitted with some diffidence and is based on thorough work in fundamental principles, with brief reading courses for those non-mathematical subjects in which description forms a large part of the course, such as road engineering, the practice of water-supply engineering, etc. Surveying and drawing are given sufficient time to insure a reasonable degree of facility in execution, for the reason that in all except the chem-

ical profession the young man's first work is likely to be in one of these branches and it is thought wise to fit him most thoroughly for that work likely to come to him first, putting him in the way of readily obtaining that general engineering knowledge that may be secured easily by reading and observation.

The following distribution of time is suggested:

Subject.	C. E. Hours.	Mech. Hours.	E. E. Hours.	Mining Hours.
Language	500	500	500	500
Pure mathematics.....	1,000	1,000	1,000	1,000
Theoretical mathematics.....	500	500	500	500
Physics, including thermodynamics and electro- dynamics.....	1,000	1,000	1,000	500
Chemistry.....	250	250	375	500
Astronomy	100			50
Mineralogy.....	100			250
Geology.....	100			250
Botany.....	100			
Bacteriology.....	50			
Drawing.....	500	500	500	500
Materials of engineering.....	250	125	125	250
Statistical structures.....	750	100	100	100
Machines	75	375	250	75
Power.....	375	1,250	1,000	350
Surveying, plane.....	500	75	75	400
Surveying, geodetic.....	50			
Railroad engineering.....	250	75	75	
Highway engineering	50			
Hydraulic engineering.....	250			150
Mechanical engineering.....	50	500	125	150
Electrical engineering.....	100	250	1,000	150
Chemical engineering	50	50	125	150
Mining engineering.....				600
Ore dressing and metallurgy				425
Architecture.....	100			
Naval architecture.....				
Political economy, physical geography, com- mercial geography, commercial and contract law, sanitation and hygiene.....	150	150	150	150
Shop work		500	300	200
Total	7,200	7,200	7,200	7,200

In this table 500 hours represents practically one exercise on each of five days of each week for an aver-

age school year. It is, of course, true that there can not be absolute uniformity in the different schools, nor is this expected.

6. Such degrees as are given should be expressive of scholastic training rather than business titles. Any man is a civil engineer who practices civil engineering, and until the practice of this profession is controlled by law as is the practice of medicine, very little value will be attached to the degree of civil engineer.

Of very considerable value, however, among educated people are the usual master's and doctor's degrees. These are what should be sought and given.

All of which is respectfully submitted.

WILLIAM G. RAYMOND, *Chairman*,
ROBERT FLETCHER,
EDMUND A. ENGLER,
F. W. SPERR,
EDWARD ORTON, JR.,

Committee.

The undersigned, in subscribing to this report, to which he has given considerable attention, in the preliminary matter submitted by the chairman, wishes to add a word concerning a policy pursued during the past ten years, which was itself the outcome of the experience of the preceding eighteen years. On the basis of hours and exercises which the report adopts as units of measurement, a collegiate course of three years in languages, mathematics and physical sciences, a minimum of sixteen exercises equals forty-eight hours per week, and about 5,184 hours in the three years; then one year of engineering studies specifically, with a

degree of B.S. at the end, thirty-nine actual weeks of fifty-five hours each, adds 2,145 hours; then a final year of post-graduate engineering study, thirty-one weeks of fifty-five hours each, adds 1,705 hours; total about 9,000 hours for the five years, with an engineering degree at the end. Between the last two years is an interim of nineteen weeks usually devoted to engineering practice, more or less remunerative. During the surveying season of thirteen weeks the usual day's work is ten hours on five days and four hours on Saturday, or fifty-four hours per week, which in strictness adds seventy-eight hours to the above total. This is not theoretical, or a proposition merely, but a working program successfully followed for ten years. In regard to the expressions of opinion by practicing engineers it is proper to refer to a paper by the undersigned, presented at the New York meeting in 1900, wherein is a brief consensus of the opinions of forty-seven practitioners and teachers in reply to a series of questions asking judgment as to the work of the engineering colleges and the qualifications and valuation of the graduates. [Vol. VIII., pp. 183-190, PROCEEDINGS OF THE SOCIETY.] Some of the opinions were given at considerable length, and the general coincidence with the views recently expressed to the chairman of this committee is noteworthy.

ROBERT FLETCHER.

DISCUSSION.

PROFESSOR McNAIR: There are a number of suggestions in this excellent report from which I certainly differ, and from which I believe a good many mem-

bers of this Society will differ. I think it is entirely too large an undertaking to attempt to discuss this report, after simply listening to its reading. I believe we can handle it to much better profit, individually and to the Society as a whole, if it can be printed and distributed, and possibly some particular persons asked to lead off in the discussion at a subsequent meeting.

PROFESSOR SPERR: I have some further tabulations pertaining especially to schools of mining which may not interest the Society at large, but which I will present if there are any here who are especially interested in that line of work.

PROFESSOR A. N. TALBOT: May I ask a question or two concerning definitions? I notice a full year is given to theoretical mechanics. From the definition as I understood it, this means the ordinary analytical mechanics, and I see no reference made to what is sometimes called mechanics of materials, or engineering mechanics, although there is a term there—the materials of engineering. Hydraulics, frequently classed with theoretical and applied mechanics, has been included under hydraulic engineering, and yet in the table in the second chart, under hydraulic engineering, is given “water supplies” for domestic use, and no mention is made of the science of hydraulics. What is the distribution of time between those studies, and what is meant by the terms used?

PROFESSOR SPERR: That is included under hydro-dynamics and hydro-dynamics is included under physics.

PROFESSOR TALBOT: Would the laboratory work be included?

PROFESSOR SPERR: That would be handled according

to the different facilities of different schools, probably either under physics or under hydraulic engineering.

PROFESSOR TALBOT: What would mechanics of materials be covered by?

PROFESSOR SPERR: That would be covered by materials of engineering.

PROFESSOR TALBOT: Is it intended that as much time be given to theoretical mechanics as is given to pure mathematics?

PROFESSOR SPERR: Yes.

PROFESSOR A. M. GREENE: If this report does not include the definition of each one of these branches I think it should.

PROFESSOR SPERR: The blanks referred to in the first part of this report gave rather minute subdivisions of these branches upon which we can easily build our definitions. I do not suppose a uniform practice with regard to those matters would be possible in all schools. The question might be asked, "How far would it be advisable to subdivide in a general suggestion as to what might be adopted?" In a general way, the committee thinks the subjects should be covered substantially as outlined, and I believe such interest has been created in this matter by the members of the Society present that each one will do what he can toward informing the committee just what he thinks should be the subdivision of time and the subdivision of subjects.

PROFESSOR GRAY: I think the matter just brought up of great importance. I believe I read the original schedule, which has been referred to, but I am unable to recall what was in it and I find the one which has just been handed round difficult to understand. I have been

for a good many years interested in such subjects as mechanics, power, electrical and mechanical engineering, but I must confess to considerable uncertainty as to what is intended to be included under the titles electrical engineering and mechanical engineering in this schedule. I think some considerable development of the schedule is desirable so that the exact intention of the committee may be made clear.

I favor the suggestion made at the beginning of the discussion, that after the paper is printed the subject should be brought up again for discussion. I do not think we can discuss the paper profitably this year and hence think it desirable that the subject be made a part of the regular programme for next year.

PROFESSOR JACOB: It is gratifying that this report contains so much valuable material which will serve as a substantial basis for future discussion. In order to know, however, whether one thousand hours is a proper allowance for physics it is necessary to have a closer subdivision. For instance, it is desirable to know how many hours are assigned by the committee to the important subject of theoretical hydraulics as well as to other subjects included in physics.

PROFESSOR TALBOT: What strikes me as unusual is the terms under which these different subjects are grouped. I think that few institutions use this classification. Of course, physics, in a sense, does include hydraulics. Would it not be best for us to include in physics only those subjects ordinarily taught in all engineering schools under the term of physics, and put such subjects as thermo-dynamics, hydraulics, etc., under usual titles?

THE PRESIDENT: The feature of the report which appealed to me most strongly was a statement made before the classification was taken up. A substantial training in principles is the goal to be reached, and this may be secured in different ways under different circumstances. An especially able teacher in some subject may be the occasion for the work taking a certain direction in one institution, while in another institution the work will, upon similar grounds, take a different direction. It is doubtful whether it is wise to put forward any special tabulation for adoption. Nevertheless, a tabulation which presents a consistent and somewhat ideal scheme is very valuable; although each of us may vary from it as much as we see fit in practice, it will still be a very helpful guide to us.

PROFESSOR WALDO: What has just been said constitutes the great value of this report. Out of such an enormous amount of heterogeneous material, the committee, by very great exertion has finally gotten a uniform basis for these various degrees, and have made a sort of general distribution of time and material. Now, we begin in the other direction, just as suggested. We have now a common general framework to which we can attach our ideas, and eventually, by working from general to particular, we are going to get something of very great value, which will rest for its foundation upon this preliminary sifting, adjusting and formulating of the committee.

PROFESSOR MCNAIR: As I understand it, the committee is a standing one and holds over, but I would like to put the matter in some shape so that the persons who are responsible for next year's program shall spe-

cifically provide for a discussion of the subject, and if a motion is necessary, I move that the secretary be instructed to take such steps in the preparation of next year's program as will lead to a definite discussion of this report.

WRITTEN DISCUSSION.

PROFESSOR MAGRUDER: I wish to express my appreciation of the work of the committee and to thank them for relieving the Committee on the Statistics of Engineering Education of part of the work which we had mapped out. Our work in this direction had progressed only to the extent of making a list of the more than three hundred titles assigned to subjects taught in one or more of the engineering colleges of the country. Our idea was that when we should send out a blank similar to the one sent out by this later committee, that everyone would find on it the names of all the different courses given in his institution in the different curricula. As the blank which was sent out went into considerable detail in civil engineering subjects, and into much less detail in other branches of the profession, and used titles of courses seldom if ever found in college catalogues, it is hardly to be wondered at that only a "few members made satisfactory returns."

I trust that another set of blanks may be sent out to practitioners in mechanical, electrical, and mining engineering, so that these branches of the profession may be equally benefited with civil engineering by the excellent work of this committee.

It is interesting to note in this report how practitioners and teachers differ in their lists of desired sub-

jects. This is particularly noticeable in the statement made "that a majority of the civil engineering instructors would omit machine design from the civil engineering curriculum, while a majority of practitioners would include it."

The report offers a strong argument for the conferral of a first degree which will indicate that its possessor has done more academic and technical work and received more collegiate instruction than has the possessor of the degree of either bachelor of arts or bachelor of science.

The committee seems to be of the opinion that the usual five-hour course for one year in chemistry is more than sufficient for mechanical engineers, and that chemical engineers do not need such subjects as strength of materials, machine design and power-generating machinery, including the general principles and methods of electric power generation and transmission. The present tendency in mechanical engineering courses seems to be to increase the work required in chemistry by adding gas, fuel, and iron analysis, as the introduction of chemistry into the foundry, and of quantitative methods into the boiler room demands that the student shall have more than the most elementary knowledge possible of chemistry. This is proved by the greater facilities with which mining engineering students are able to work out a heat balance for a boiler test than can their mechanical engineering classmates who have had less work in the chemical laboratory. When the same heat balance is required for a gas-producer and a gas-engine, the mechanical engineering student must begin by studying the chemistry of quantitative gas

production. As a chemical engineer is a person who skilfully manufactures on a large scale commercially with the aid of machinery the same compound which the chemist makes in the laboratory on a small scale, it would seem self-evident that he must be familiar with the construction and operation of machinery, and therefore that the more he knows both theoretically and practically of the strength of materials, machine design, power- and electrical-generating machinery, and of other mechanical engineering subjects, the better equipped he will be for a successful career as a chemical engineer.

FIELD WORK IN CIVIL ENGINEERING AT IOWA STATE COLLEGE.

BY ANSON MARSTON,

Dean of Division of Engineering, Iowa State College.

Local conditions exert a large influence to affect engineering courses at different institutions, and in no particular is this more true than in instruction in field surveying. Evidently, an institution located in the heart of a great city can have small opportunity for carrying on field work while college is in session in direct connection with its class room work, and may be forced to transfer practically all of its field work to the summer surveying school. The Iowa State College, on the other hand, owns over eight hundred acres of land in one body, and is located in a country district where the surrounding private land owners do not object to the carrying on of surveys over their lands by students. The conditions are, therefore, very favorable for carrying on a considerable part of the field work in direct connection with the class room work in surveying and railway engineering.

Other conditions also have contributed to a comparatively early and extensive development of the instruction in field work at the college. Located in a state whose interests are so preëminently agricultural, a very large part of the students are drawn from agricultural communities. These students are excellent material, coming to college as they do usually with earnest purpose and with training which has made them willing to

do the hardest kind of work while at college, and in their after-professional careers. However, these agricultural communities are lacking in much of the direct contact of the daily life of the community with engineering industries and interests which gives to manufacturing and urban districts more of what may be called, for lack of a better term, an "engineering atmosphere." It is, therefore, very desirable that our engineering students at as early a date as possible should be given some line of technical work which will serve to help inculcate in them the proper engineering spirit and enthusiasm.

On this account instruction in "field work" has been introduced in the freshman year, where it occupies seven actual hours every week. The freshmen are assigned to sophomore parties in land, drainage, topographical and municipal surveying and to the junior parties in railway engineering. The freshmen serve as chainmen and rodmen of these parties and acquire familiarity with the instruments and methods of field work in very much the same manner as they would acquire such knowledge if they served on field parties in actual engineering practice. It is found that this preliminary course in "field work" enables very much more to be accomplished during the sophomore and junior years than was formerly the case when the students had to acquire their first familiarity with field surveying methods at the same time that they were pursuing the class room work. In addition, this preliminary course does much to help arouse the professional spirit which will make engineers of the men.

In this connection it may not be out of place to discuss

briefly what should be considered the objects of instruction in field surveying at engineering schools. Doubtless the immediate object, which would first occur to every one, is to give the students such knowledge and practice in the handling of surveying instruments and in the processes of field surveying as will enable them to successfully carry on surveying operations in such positions as they may properly secure on graduation. If this were the only object then too much time of an engineering course should not be given to field work, for close observation by the writer of the professional careers of many graduates of technical schools has convinced him that the acquiring by the student of special knowledge of the multitudinous *details* of each branch of the profession can best be left, in the main, to the post-graduate school of actual experience in the active practice of the profession. It is of course natural that practicing engineers should have a tendency to conclude that any engineering course should be designed to turn out engineers perfectly equipped from the first to carry on the various special branches of engineering professional work. On the contrary, the writer believes that the important part of an engineering course consists in giving the proper foundation training in mathematics, sciences, and the general principles of engineering work, not forgetting some culture training. To attempt to teach in college all or the principal part of the innumerable *details* of the various special fields of the profession would be very much like attempting to teach all about chemistry, or any other science, before sending the student to the laboratory where he may apply and test his knowledge as he acquires it. The lab-

oratory for engineering is the actual practice of the profession.

Field instruction in surveying and railway engineering, however, constitutes laboratory work for the student who is studying these subjects and may properly receive a comparatively extensive development on that account. It helps very much to give life to the work.

The engineer engaged in surveying operations has to handle not only the surveying instruments but also parties of men. Moreover, he must be capable of planning and directing field operations in such a way as to secure the desired results with least expenditure of time and money and with the greatest reliability in results. Our course in field instruction at the engineering schools should be planned with a view to giving the students training in these respects as well as in the actual use of surveying instruments. The work should be organized in such a way that each student will have thrown upon him the responsibility of handling parties of men and planning field operations.

Another object of instruction in field work in engineering courses may properly be to help inculcate in the students the proper professional enthusiasm, or *esprit du corps*. In this respect it may be considered to occupy very much the same relation to the education of an engineer as military drill does to the education of a soldier. The engineer has this advantage over the soldier, however, that frequently during the vacations of his college course he can secure employment at actual engineering work, while the soldier must wait for a war to serve his apprenticeship. Instruction in field work should be arranged so as to turn the attention of

engineering students, so far as possible, toward engineering vacation work and to fit them to secure it at as early a period in the course as possible.

At the Iowa State College the field parties normally consist of four men, of whom usually two men are freshmen acting as chainmen or rodmen. One of the more advanced classmen acts as captain of the party during half of each semester, alternating with the other. The advanced classman not acting as captain serves as instrument man. The field parties are numbered and so far as possible detailed instructions for the work of the different parties are bulletined prior to each day's work. While an instructor is actually in the field giving general directions, the captain is held responsible, so far as possible, for planning and directing the work of each party. The captain receipts for all equipment taken out by the party and is held responsible for it until his receipt is cancelled on the return of the equipment in good order. At the close of each day's work each captain makes a report of the work of his party during the day on a printed blank form. The forms used for receipts, and for reports of sophomore and junior work are given herewith.

CIVIL ENGINEERING INSTRUMENT ROOM,
IOWA STATE COLLEGE.

Party No..... Date.....190....

Received the following instruments in good order

ARTICLE	MARK
.....TRANSIT	
.....LEVEL	
.....TAPES	
.....PICKETS	
.....ROD	
.....PINS	
.....HATCHET	
.....PLUMB BOB	
.....	
.....	
.....	
.....	
.....	
.....	

(Signed)

Returned

IOWA STATE COLLEGE,
CIVIL ENGINEER DEPARTMENT.
Sophomore Field Work.

Party No..... Date.....190....

Report on work of this date is as follows:.....

NOTE—This report should show your progress on the entire work connected with the problem assigned. It may also indicate the work next to be pursued.

For Notes see Field Book No...Page... Capt. of Party

Time.....M. to.....M.

Total.....hours.

RAILROAD SURVEYING, IOWA STATE COLLEGE,

Civil Engineering Department.

 Report of Party No.....for the.....of.....190....

On this day we.....

The following men served on the party	.....	.....
and for the freshmen I recommend	.....	.....
the grades indicated.	.....	.....
		
		
		

 Respectfully.....*Capt. of Party.*

All receipts and reports are preserved until the end of the semester.

A word may be said here regarding the best method for keeping and giving out the surveying equipment. At the Iowa State College the surveying equipment is kept in an instrument room, with an assistant in charge. The equipment needed for each party is made up beforehand and is given out over a counter. With the large number of students whom we have taking this work we find that there is some delay in getting the parties promptly started at work at the beginning of the field periods. If the surveying equipment was extensive enough it would doubtless be more satisfactory to have the sets of equipment in lockers, giving the captains keys, and holding each party responsible for the condition of all equipment in its locker.

At the Iowa State College, instruction in land surveying, city surveying, topographical, hydrographic, and mine surveying extends throughout the sophomore year. The work includes two class room periods and seven hours of actual field and office work per week. The instruction in railway engineering extends throughout the junior year, and includes two class room periods, three hours of office and seven hours of field work per week. During the last year the class in junior work was divided into three sections, each of which was given a separate problem in railway location, involving preliminary surveys, paper location, location surveys, estimates, etc., for about six miles of line.

In addition to the field work which is carried on during the regular college session, the civil engineering work at the Iowa State College includes a summer school of surveying lasting fifteen days, immediately following commencement each spring. The summer surveying work is required during each of the three vacations of the course, but actual engineering vacation work with reputable engineers or corporations may be substituted. Students are encouraged to secure such engineering work during the summer and a large number of them do so, so that comparatively few attend the summer camp during all three sessions. The department owns a complete camp outfit. During the summer camp the students employ cooks and pay their living expenses on a coöperative plan.

While at least two or three members of the civil engineering faculty are always present, the operations of the summer camp are, so far as practicable, immediately under the direction of a set of student officers, partly

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elected and partly appointed by the department. These officers consist of a chief engineer, an assistant chief engineer, a chief draftsman and a computer. There are also three commissaries, chosen by the students of the respective classes, to have charge of the coöperative boarding arrangements. The professors at the camp assist the student officers, of course, by advice, and actually take part in some of the field work, but so far as possible the work is directed by the student officers.

For several years the camp has been located on the Des Moines River, the operations of each year beginning where those of the preceding year stopped. A stadia topographical survey is made of a strip about two and one half miles wide and approximately equally divided by the river. The country is to a considerable extent covered with timber, and is very rough, although the hills are only about 200 feet above the river. In the stadia work the recorder computes all readings in the field as fast as they are taken, carrying a stadia slide rule for this purpose and at once applying all checks. The captain plats all the stadia notes in the field, and sketches in the contours and other features of the topography. For this work he carries a traverse table on a tripod, light enough to handle with one hand, the table being provided with a needle for orienting. In sketching topographical features he runs many approximate traverse lines, orienting the board, sighting along his straight edge, and pacing distances. The field sheets are made on a scale of five hundred feet to the inch, protractor sheets being used, while the final map is on the scale of one thousand feet to the inch. It is found that, with due care in the use of the traverse

table, contours and other features of the topography can be sketched in over a strip three thousand to four thousand feet wide with all the accuracy required for the scale on which the maps are drawn, and without an excessive number of side stadia readings.

A primary traverse line is run on the most favorable ground in the river valley, and a system of triangulation between points on opposite sides of the valley is also used as a basis for the work. Besides the topographical and triangulation work, gaugings of the flow of the river are made with a current meter at different stages, and the flow of tributaries is measured with temporary dams and weirs. Soundings of the river and maps of its channel and bed are also made.

As indicating the extent and nature of the topographical work done at the summer camp, a topographical map of the work of 1904 is given herewith.

In conclusion the writer would say that in presenting this account of the instruction in field surveying at the college with which he is connected he has not meant to claim special originality for most of the features described, nor to say that exactly the same details should be followed out elsewhere. As he pointed out at the beginning of the paper, circumstances alter cases, and the work of each school will properly be developed with special reference to its own local conditions.

DISCUSSION.

PROFESSOR L. S. SMITH: How do you fix the altitudes and depressions in your stadia course? I do not see how that is determined until the circuit is closed.

PROFESSOR MARSTON: The notes are computed as fast as they are taken, and the foresights are compared at once with the backsights. The azimuth is compared with the magnetic bearing. The notes are platted in the field as taken.

PROFESSOR L. S. SMITH: I would like to ask if it is not your experience with inexperienced students that during the first week a large number of errors are made, and when you come to plat the survey, it is often found in error, so that the work does not close? From my own experience with students for ten years or more, I am inclined to think that a large number of lines would need to be re-run. I refer to the first part of the work—the first week's work—the first few traverses.

PROFESSOR MARSTON: In answer to that question I would say it is necessary to bear in mind the description of the full course in field work. These men who go to the first summer camp have had one year's experience in college work, including special instruction in stadia work. The captain of the party is a man belonging to one of the upper classes, who has already had some experience at stadia work. The students are given a drill at the college in stadia work before they go to the camp. So we do not have the amount of trouble we would have if all the men were inexperienced. We do have some trouble in the first start of the stadia work, but we close the first two days' work immediately, and we have level checks run with an ordinary level for the purpose of checking the elevations.

PROFESSOR IVES: The methods of making a topographical survey which are used at the University of Pennsylvania may be of interest. A triangulation system

is laid out as usual; the base line is carefully measured as are also the angles. The angles are adjusted and the sides computed. The system is then plotted to the desired scale. Portions of the system are plotted on protractor sheets so arranged that they may be pasted together afterwards. Each party takes one or more of these sheets and secures the information necessary for putting in all desired features. The stadia method is used, a slide rule and sketching table being taken into the field and the reductions made and the map plotted. A complete map is thus secured and if errors are made the work may be at once retraced. The stadia lines are from one half to one mile in length and are tied to the triangulation stations, the elevations of which have been previously determined by lines of wye levels. The particular advantage of this method is that a correct map is available on the completion of the field work. This is especially important where the scene of operations is, as in the present instance, at some distance from the college, and where a map is to be made the next term by each student. A party consists of five members and after three or four days in the field, the men become fairly proficient.

The problem of conducting the field work in the larger cities is a serious one, but not as serious as one might think. Considering four or five of the leading technical institutions in the East, such as Harvard, Yale, Columbia, the University of Pennsylvania, and the Massachusetts Institute of Technology, it is seen that they are all situated in large cities and it is difficult to conduct the field work on this account. In an elementary course in land surveying the condition stated is not a

serious drawback, as much of the work, such as leveling and many of the simpler exercises, can be conducted in the city. For the more extended problems it becomes necessary to take the class outside the city limits, either during the term time or in a summer session. At the University of Pennsylvania the more extended exercises are conducted at the Flower Farm (two miles from city limits) during the term, and the class is taken to some distance from the city at the end of the year for more extended surveys.

There are four different ways of arranging the theory and field work in surveying. First, where the recitation work is given during the term, supplemented by sufficient field work to give the students a clear understanding of the construction and use of the instruments, and possibly by a longer continuous session during the summer. Second, where the recitation and lecture work are given during the term with no field work, all field work being given in the summer session. Third, where no recitation or field work is given during the term, both being given in the summer school, a lecture preceding the field work of the day, with examinations at intervals. And fourth, where the men are started in field work before the opening of the fall term and before recitation work has been given but with sufficient directions for its successful conduct.

The first of these methods is pursued at the University of Pennsylvania, the second at Columbia University, the third at Harvard, and the fourth at the Sheffield Scientific School of Yale University.

I think there is a tendency in engineering schools to transfer the work in surveying from the freshman to

the sophomore year. The men are better prepared for it in the second year, and in many schools from twenty to thirty per cent drop out at the end of the first year. By introducing this work in the sophomore year most of the poor material has left the class and the remainder can receive better attention.

Another important matter in connection with field work is the make up of the parties. I find that it is better as a rule to put men in a given party regardless of individual ability. There are perhaps two exceptions to this rule; first where men have had some practical experience but not enough to warrant excusing them entirely from the work, and second where men are so deficient that they will almost surely drop out of the class. The segregation of the good men from the poor men I do not believe in to any great extent, and if done at all it should not be made too noticeable.

In field work it is particularly important that the men shall report on time. I think we have solved this problem. For field exercises during the term we have a rule that unexcused tardiness will exclude the man from work for that day, and that unexcused absences must be made up in a manner and at a time satisfactory to the department. Since the adoption of this rule students have seldom been late or absent, without notifying us beforehand.

On a summer survey certain men may desire to take breakfast at a later hour than the rest of the class and therefore will not be ready to start the day's work with them. We solved this problem also on our last trip. Men who were late in the morning were given preference in performing the necessary office work in the

evening. The result was that there were only four or five men late in a class of thirty-two members.

PROFESSOR SPERR: I think some subjects should always be taught with a certain amount of practice, in order that the student may advantageously master the fundamental principles of which we have heard so much at this meeting. And surveying is especially one of those subjects. I do not believe that very much successful teaching of surveying can be done without some practice. Where the school is so situated that it can carry on more or less surveying practice throughout the year, the course in surveying may be spread out through the whole year. But with us in Northern Michigan it is too cold in the winter time to do field surveying work. Therefore we throw all our surveying work into the summer months. And we teach surveying with practice. I object to the division of the subject of surveying into theory and practice. We devote the whole day to the work of surveying during twelve weeks of the summer months. Lessons are assigned daily in the textbook in advance of the field work. The students are supposed to take their text-books into the field with them and study the subject with the instrument in hand, while they are doing the work. They are required to write out answers to questions given them in the recitation room before going into the field in the morning, and then to recite to their instructors in the field.

There is some advantage in having the more advanced men take charge of the party, but with us the surveying work begins about the beginning of the sophomore year for all students. We try to carry out the scheme of having the instrument man given charge of

the party during his time at the instrument. I do not think this can be carried out as successfully as the scheme of having the higher classman in charge of the party, because men will rebel at being bossed by their fellow classmen. At the same time I think there is an advantage in having them get all the different parts of the work in the shortest possible time. Following the course in field surveying we have a course in mine surveying which begins with reading and problem work which might be called theory, perhaps, but it is largely practice, and this is followed by mine surveying, with practice in the mines.

PROFESSOR TURNEAURE: There appears to be a decided tendency among engineering schools to require a certain amount of summer work, especially for civil engineering students. It is a fair question whether it is not desirable to lengthen the civil engineering course, and possibly other courses, by the addition of summer work. I should be glad to hear from other schools as to their practice in this respect. I suggest as a good subject for a paper next year, "Summer Schools of Surveying."

PROFESSOR MARSTON: In connection with the question as to how much of the instruction in field surveying should be relegated to the summer vacation, it seems to me that the ideal way to lengthen out the course would be for every student to work for some reputable engineer during the summer vacation; and it seems to me there would be objection on the part of the students with whom I have come in contact, to a plan of forcing them into a college summer surveying school, so as to prevent their getting this summer vacation work. I

find it is possible for an increasingly large percentage of them to get summer work at engineering, or something closely allied to it, as the years go by.

PROFESSOR BULL: I would like to ask if these students can altogether be excused from this work?

PROFESSOR MARSTON: Yes, it is possible, although nearly every student takes the college summer school work at least one summer.

PROFESSOR SMITH: The ordinary college boy is a pretty bright sort of fellow, and he works many schemes. Here is one scheme I have seen worked. He comes and wants to substitute some surveying he has had in the field for some work required in the beginning course. Then he offers the same experience for a credit in a later railroad surveying course, and finally again for a credit in the summer school of surveying. The experience students get in this way is a narrow experience. Professor Whitney used to say that he never saw the old adage so well exemplified, "A little knowledge is dangerous," as in a boy who has had a little experience in the field. I think a full equivalent should be given and received.

THE PRESIDENT: We have all had an experience somewhat similar to Professor Smith's. In the future I expect to give men who have had outside experience and who wish to be excused from field work, some sort of examination so that I shall have pretty definite knowledge myself that certain things that ought to be accomplished, have been accomplished. In railroad work, for instance, men who have had outside experience might readily enough have no notion whatever how to keep a set of notes in railroad work, and a

few suitable tests would oftentimes save considerable trouble. To illustrate another point, a few years ago, a man who had been for a short time at our institute and had been away for a long time in practical work, came back for a couple of years that he thought he needed in order to make himself a first-class man. He was a man of large experience, sufficient to entitle him to membership in the American Society of Civil Engineers, and I speculated somewhat as to his effect on the class. The result was that there was no influence in that class for that year for good that compared with the influence which that man with large experience exerted. On the other hand, the man with very little experience is apt to do a great deal of harm unless the opportunity is taken occasionally to show the class there are a few things that the man does not know. That, oftentimes, is very helpful in the class. What Professor Sperr has said with reference to theory and practice in surveying, he intended, I think, to apply more to surveying than to railroad engineering and field work. There is one exercise in field work that I conduct deliberately from the opposite standpoint. The laying out of ordinary simple railroad curves is studied in the class during the first term. The field drill in that work comes in the second term, and I make it a point always in announcing the appointments for field work, to avoid any suggestion as to what the kind of work is to be; I take pains to avoid giving the students an opportunity to prepare upon the work. My idea is it is very valuable to take men out into the field for simple curve work at a time when they have had opportunity to forget all about it; my experience has been that practically all the men who

have done good work in term and who have passed their examinations properly, will take up that simple curve work perfectly well when they are absolutely rusty in it. On the other hand, in slope staking the theory is somewhat intricate, and preparation is necessary if the students are to make satisfactory progress with this work from the start.

There is one point with reference to Professor Marston's paper, in relation to the place in the curriculum where the surveying shall come. There is much force in the idea that something of that work can be done to advantage in the freshman year. It is not so managed in our institution, but to arouse the professional spirit at an early date is very important, and if a man has gone far enough in his surveying work to be of some use to the outside engineer during even a part of his first summer vacation his opportunity for getting work is materially enhanced and some advantage results in that way. If the work is done in a short summer school or summer course immediately after the examination, the weeding process will have been in part effected; the men, on the whole, will be put in better shape for securing summer work the first year, and the hardships will have disappeared. Certainly something can be said in favor of getting surveying work on foot at an early date. Surveying is not work of sufficient severity to make it necessary to put it very late in the course.

PROFESSOR IRA O. BAKER: Professor Marston speaks of having the surveying in the first year so that the freshman can get work during the first summer. It seems to me that that will work in the opposite way

from the one implied, since the surveying will occupy the earlier part of the summer, and hence it will be harder for the freshman to get work, as every one knows that it is easier to get work early in the summer than later. Again, it seems to me that Professor Marston's surveying is pretty nearly of the nature of seeking to perfect the men in mere field routine; that is, the students have had the principles, and he seeks to give them experience. It seems to me that it is better that they should get their experience under actual conditions, rather than under the artificial conditions of a summer school. Professor Sperr, if I understand him rightly, said that his students took text-books to the field; and I am not sure, but think he said he had recitation there.

PROFESSOR SPERR: Yes.

PROFESSOR BAKER: I do not see how any one can conduct recitations of any great value in the field, as the student needs the quiet of his room in which to study, and the teacher the facilities of the recitation room for the recitation. It seems to me that the difficulties are still greater in the matter of instruction in drawing. I do not see how one can teach much, if any, more than field routine in camp. Some years ago I investigated this matter a little. I was told of a particular institution which, it was claimed, had an excellent summer surveying class. As I happened to know the instructor I wrote to him for particulars. He answered all my questions, and explained in four or five pages how lessons were assigned for night study. He was enthusiastic in his praise of the summer school in surveying; but at the close of his letter he dropped off into chat, and explained what a fine time the students had boating.

playing tennis, going to a near-by summer resort hotel to dances, etc. It seemed to me that the confession in the last part of the letter cast at least a doubt upon the conclusions drawn in the first part. I am doubtful if anything more than field routine can be taught in a summer surveying camp, except possibly under such exceptional cases as have been mentioned where the class is quartered in a summer-resort hotel before the opening of the season. It is possibly true that some institutions are so located that the summer school affords practically the only opportunity to teach field routine; but I think that the best results are obtained only where the field routine and the recitation work go hand in hand, and that ordinarily they can not be united satisfactorily in a summer camp.

PROFESSOR JACOBY: No one here has had more experience in the field than Professor Crandall, and I would like to hear a word from him.

PROFESSOR CRANDALL: Our experience with what might be called summer school work, although conducted in term time, began in 1874. We took out our junior and senior classes, and from that time to this we have never had any trouble with hilarity, or lack of inclination to do good thorough work. Our survey this year was confined to the junior class. We had a party of about seventy in the field this summer, with four instructors. The effect with reference to summer employment has been that about one third of those men have been able to find work this summer, ending their field survey on the tenth of July. Last year two thirds of them, as sophomores, found work. And more men of the under-classes found work this summer than of

the junior class. One half or two thirds of our men are men who could not attend during the four-year course, except for the work in vacation. I will say our experience in accepting practical work for surveying is leading us to be more strict in regard to accepting substitutions. Practical experience may mean a good deal, and may mean nothing, so far as surveying is concerned. We have never accepted practical experience, except in conjunction with examinations. I notice that Columbia will accept no student's survey work, unless it has been done under instruction at some institution.

PROFESSOR BAKER: I would like to ask Professor Crandall whether he ever tried requiring a certificate from the man under whom the student has worked?

PROFESSOR CRANDALL: We usually do require it, but what a man's experience has been is pretty hard to judge from the certificate. Ten years ago very few men came to us with any practical experience, but the number has been increasing very rapidly of late, and we find a very marked improvement in the class room, due to a few of the men having had practical experience.

PROFESSOR SPERR: We do not let them loose. We have had no trouble yet with keeping the student at work. We give them enough to do, so that we have had no trouble at all with what is known as coltishness or kiddishness. The instructors get after them pretty closely and keep them busy.

PROFESSOR BAKER: Isn't there considerable difficulty in conducting a recitation or a quiz in the field?

PROFESSOR SPERR: We do not pretend to conduct a formal recitation in the field, but we do ask questions to find out whether the student knows what he is doing.

PROFESSOR BAKER: Is that recitation?

PROFESSOR SPERR: The recitation is all written in the morning before going out. We have our field all around our college, not being located in a city. During the railroad surveying more time is occupied in the lecture room and draughting room.

PROFESSOR JOHNSON: It might be apropos for me to say a word about a summer surveying camp which I had occasion to visit a few weeks ago. It was the camp where all the Harvard instruction in land and railroad surveying is given. There were one hundred and forty students at work in a way which I think would dispel anybody's doubts about the possibilities of an efficient summer camp in the woods. The one hundred and forty men were out of bed at six in the morning. At seven o'clock they had a lecture, and at eight o'clock they were in the field. They carried their luncheon with them. In charge of the field work there was an abundant corps of instructors (one to every twelve students), and when they get back in the afternoon their taste for hilarity is by no means troublesome. I think if Professor Baker should see that camp his fears would disappear.

PROFESSOR SPERR: Did you have anything in the way of recitations in the camp—quizzes?

PROFESSOR JOHNSON: I did not have charge of the work. I was merely a visitor, but I can say that there are stated written tests every Saturday, and several announced oral quizzes during the course. In addition the professor in charge and his chief assistant spend all the working hours visiting the different groups at their field work, asking them questions as well as explaining difficulties.

THE PRESIDENT: One summer I attended our summer school of topography. The school is not large, because it has not been compulsory except for a few men taking a special line of topographical work; there were about twenty or twenty-five men. They were stopping at a moderate sized hotel on the edge of the Adirondacks. That year there certainly was no difficulty as to the behavior of the students. During other years I have been in close touch with what has been going on, through my intimacy with the professor in charge of this summer school, and I am sure there is never any serious difficulty with reference to the behavior of the students. The people who give accommodations to students are always more than ready to have them return. The experience with us has been very uniformly in the direction of entirely satisfactory behavior. The day has been differently arranged as to hours from that which Professor Johnson has spoken of, but in the amount of physical exertion required they can not be very far different; when that matter is taken care of, the other difficulty will never be very serious.

PROFESSOR L. S. SMITH: Practical experience in the field is accepted at Wisconsin in lieu of part of the required four weeks of field practice in the summer school of surveying. Work as rodman is not accepted; credit being given only for instrumental experience and then only after a formal statement from the engineer, under whom the student worked, describing the character of the work and the proficiency attained by the student. A large proportion of our civil engineering students find summer employment on the United States Geological Survey as field assistants or levelmen or on railroads

in similar work. Such students are credited with the topographic portion of the summer school field work, but are required to do the geodetic field work of the survey in course.

We consider that the handling of instruments of high precision, like large theodolites and precise levels and the office discussion and adjustment of such work discloses to the students, as nothing else can, the causes and relative importance of errors of measurement as well as the best program for their elimination. After such an experience the student should be able to get better results even from inferior instruments.

The answer to Professor Baker's question, why a summer school for such field work is preferable to including it in regular term time is, that to carry out this work successfully, the student should be freed from all other distracting studies. The work must be organized and carried out under circumstances similar to those obtaining in actual practice. This calls for long uninterrupted time periods of from two to five weeks. During term time the maximum period for field practice may be regarded as only a day. Another reason may be found in the already crowded program for term time.

During the past five years the speaker has had charge of a summer school of surveying in a town of 6,000 inhabitants located on the Wisconsin River about forty miles from the university. The average attendance has been about fifty. It is significant that repeated requests, both from hotels and from private citizens with whom our boys have roomed or boarded, are made each year for their return. As a further proof of the good reputation earned by these young men, I will

state that for the past three years the mayor of the city has placed at our disposal for office headquarters a very large room in the new \$25,000 city hall. I need hardly add that the boys are justly proud of their reputation, and do their part to maintain it.

The suggestion which has been made that it is difficult to maintain discipline under such circumstances has no basis in fact. The daily program is so full that after the day's field work has been checked over and plans for the following day made, the boys are tired enough to enjoy a good night's rest. The students pay their own expenses and feel that they are working for *themselves*, not merely for an instructor in order to get a certain credit.

PROFESSOR JACOBY: In case the discussion on the summer school in surveying is to be continued at the next meeting the hope is hereby expressed that those who take part in it will not only state the methods or plans used in their own practice but will also give the reasons why they were adopted, together with any special conditions which may not exist elsewhere.

PROFESSOR MAGOWAN: The general subject of field work is one of great interest to me, but some of the subjects that have been mentioned in the discussion of this paper are of even greater interest. One of them, mentioned incidentally by our President and also by Professors Crandall and Smith, relates to the desirability of having students in classes who have had actual engineering practice. That I agree heartily with the statements that have been made regarding this, may be inferred from the fact that I have repeatedly told the young men with whom I have come in contact at our

university, that personally I wish that every one of them could have at least a year's experience in actual engineering work sandwiched in between the years of their regular university course. I have been criticised somewhat for taking this position, but I am ready to defend it. Some have said, "If you let the young men get away, the probability is they won't come back." I grant there is some danger here; but if the young man is possessed of the right temperament, and desires to make the most of himself, and you can offer him the proper inducements, he will return in due time, and his presence in the class room after a year, or perchance years, of experience, is beneficial to the other members of the class, and his experience has been and will be helpful to him.

Regarding the question as to whether surveying should be commenced in the freshman or sophomore year, I am free to say, that having tried both conditions, I very much prefer that a short course in elementary surveying be given during the latter part of the freshman year, which shall consist largely of simple problems solved in the field, and the securing of a more or less intimate knowledge of the use of the compass, transit, and level, in order that more extensive surveys may be made during the first part of the sophomore year, when the weather conditions are ordinarily such that outdoor work can be prosecuted with considerable vigor, and desirable continuity.

I want to call attention to one preliminary exercise in surveying, which may be old to all of the members present, but should it be new to any one, I want to commend it to that one, and ask that he try it. Require the stu-

dent to use a pair of surveying instruments which nature gave him, namely, his legs. Require him to make a pacing survey of a tract of ground near the class room, and to record in his own notes the results of his work; then before going on with the more serious work of the term, require him to plat his notes, or to attempt to do so. I know of nothing that impresses upon the student more emphatically than does this simple exercise, the necessity of constant care in taking notes. After having met several difficulties in closing his survey and having been asked to go out on the ground and find out for himself where and what the trouble is, his future notes will, in all probability, be more clear, full and concise than they otherwise would have been.

PROFESSOR MARSTON: I do not feel that I can add very much to what has been said. I have been pleased with the discussion. We do not accept substitutions for sophomore field work. We find the experience obtained in outside practice does not cover the entire field of the field work in connection with general instruction in surveying. We do accept such work, on presentation by the student of a certificate, for our freshman field work. In a case where a man may have had several years' experience in railroad surveying, we accept such work for the field work of the railway class, but not for the office work of the course. On the other hand, we do accept outside work for the course in summer work. One of the objects is to force the students to get outside work. They must either get outside work or take our summer camp work.

THE NAVAL ACADEMY AS A TECHNICAL SCHOOL.

BY IRA N. HOLLIS,
Professor of Engineering, Harvard University.

The education of youth may proceed along two lines: The first, or what might be called the natural method, is by means of lectures, conversations, and conferences, acting as a stimulus to the student to educate himself. He must arrange his own time and do what reading he sees fit. The only tests are examinations after long intervals. The other method is one wholly of control or direction. Every moment of the time is arranged, and all of the student's work is planned for him. There are no lectures and he must recite from text-books. The first of these two types exists only in modified form in the United States. Harvard University approaches it very nearly, where, in the college, the system is one almost wholly elective, conducted mainly by lectures and conferences. The second of the two types exists at Annapolis and West Point, where the control is parental. The technical schools throughout the country probably approach nearer to the Annapolis type than to that of Harvard, although large classes and small means force the larger schools towards the methods of the latter. It is by no means clear which of the two types is the better in the long run for young men aiming towards the engineering profession. Schools are too often measured by the few graduates who have achieved reputations, and we must remember that large men are

not the product of schools or methods, but rather of inheritance and home influence. What a technical school must aim at is to train the average boy to do the ordinary routine work of engineering satisfactorily, leaving to experience and the world the development of reputations. A school must be judged by the large mass of graduates it sends out. Measured from the standard of initiative and accuracy it seems to me that most technical schools are deficient, and have something to learn from the military schools. There is a theory held by many that the natural method of education promotes independence and initiative, thus leaving students from the civil schools more able to grapple with the problems of daily life and of commercial undertakings than graduates from a military school are likely to be. My own experience leads me to think that the popular impression is wrong and that the Naval Academy is more capable of developing the power of initiative along given lines than a civil institution.

The Naval School was founded in 1845 by George Bancroft, Secretary of the Navy, in the administration of James K. Polk as President. It was formally opened on October 10 of that year. The course was fixed at five years, of which the first and last were to be spent at sea. The whole theory of the course was based upon the demand for practical seamen, who knew navigation, gunnery, and sails. It was highly technical and gave comparatively little time to general education. As sails have gradually disappeared from ships and steam has taken their place, machinery has become the most important factor in naval warfare. At first the school responded slowly to the changed conditions and

it was not until 1884, when cruisers and battleships without sails were common, that the course approximated to that of an ordinary engineering school. Since 1898 its curriculum has been almost wholly engineering, with sufficient mathematics and mechanics to enable the midshipmen to understand the engineering courses well.

The course is in theory six years, four of which are spent in undergraduate study at Annapolis, and two at sea in what might be called graduate apprenticeship. The final examinations for commissions are held at the end of six years and the young officers then receive the commissions which correspond more or less to the professional degree in technical schools. There have been many attempts to have the course reduced to four years. As will be seen, the course of studies is more elementary than would be found in the best technical schools and there seems to be no place for graduate study. The chief merit of the school is in the thoroughness and system with which its work is done.

There are in general four branches of engineering which are studied at the Naval Academy: marine or steam engineering, electrical engineering, ordnance engineering, and construction or ship engineering. These form the backbone of the course of studies. To them must necessarily be added instruction in navigation and a large amount of practical instruction in seamanship, including the handling of ships by means of sails. Seamanship, at the Naval Academy, has, however, come to mean the practical knowledge of all the elements which go to make a ship and the practical skill in handling the ship as a whole or any one of its elements separately. In this sense, seamanship is nothing but a

department of the larger subject of engineering. The Naval Academy is therefore essentially a school of engineering, of a highly technical character. Some instruction is given in subjects intended to enable an officer to express himself clearly in his reports and to be able to understand or converse with foreign officers. It might be said truthfully that it is the only school in the country (except the professional schools for law and medicine) which has cut loose from the idea of general education and which confines its instruction absolutely to the needs of the service. The theory is that a young officer must be a gentleman, he must be able to express himself concisely and clearly on any subject related to the service, that he must be able to deal intelligently with foreigners in the interests of his country, and that he must know his profession. Outside of this there is no attempt whatever to give an officer broad mental resources or literary equipment of any kind. It might be fairly claimed that an officer's contact with the world and with people of all nations would be of itself sufficient outside education. To some extent this claim is justified. It has always seemed to me, however, that the merit of the Naval Academy is in its rigid discipline. Ordinary excuses for delinquencies are not accepted, as they are in civil schools. If a student fails his examination, no consideration is taken of the fact that he has been sick or unlucky. He pays the penalty of failure. It seems to me that in this way a sense of responsibility is taught as it can not be in a school dependent upon tuition.

Another inducement to efficiency is the reward ahead of a successful graduate. Every midshipman knows

that a commission awaits him and he is absolutely sure of support all his life in case he passes the examinations. Furthermore, he has every evidence that the service is attractive and that its officers have the respect of the nation.

The course of instruction begins in June every year, the fourth class having been admitted by examination under the auspices of the Civil Service Commission. These examinations are held in all of the large cities in the country. They cover the following subjects, a description of which is taken bodily out of the annual register of the Naval Academy.

Reading and Writing.—Candidates must be able to read understandingly, and with proper accent and emphasis, and to write legibly, neatly, and rapidly.

Spelling.—They must be able to write from dictation, paragraphs from standard pieces of English literature, both prose and poetry, sufficient in number to test fully their qualifications in this branch. The spelling throughout the examination will be considered in marking the papers. The Academic Board are instructed not to reject a candidate whose only deficiency is in spelling when the mark therefor is above a certain figure, to be fixed by the board, subject to the revision of the department.

Punctuation and Capitals.—They must be familiar with the rules for punctuation and for the use of capitals. In order to test their knowledge, sentences will be given for correction.

Grammar.—Candidates must exhibit thorough familiarity with English grammar; they must be able to analyze and parse any sentence given, showing clearly

the relations between the different parts of speech, and giving the rules governing those relations. The subject and predicate in the sentence must be given, with modifiers (if any), and also the part of speech, and kind, case, voice, mood, tense, number, person, degree of comparison, etc., as the case may be, of each word, and its relation to other words in the sentence.

They must be able to define the terms used in grammar, a number of which will be given as a test of their knowledge.

A composition on one of three subjects will be required.

Since the school grammars used in different parts of the country vary among themselves in their treatment of certain words, an answer approved by any grammar of good repute will be accepted.

Geography.—Candidates will be required to pass a satisfactory examination in descriptive geography, particularly of our own country. Questions will be given under the following heads: The definitions of latitude and longitude; the zones; the grand divisions of land and water; the character of coast lines; the climate of different parts of the United States; trade winds; the direction and position of important mountain chains and the locality of the higher peaks; the position and course of the principal rivers, their tributaries, and the bodies of water into which they flow; the position of important seas, bays, gulfs, and arms of the sea; the position of independent States, their boundaries and capital cities; the position and direction of great peninsulas and the situation of important and prominent capes, straits, sounds, channels, and the most important

canals, great lakes, and inland seas; position and political connection of important islands and colonial possessions; location of cities of historical, political, or commercial importance, attention being especially called to the rivers and bodies of water on which cities are situated; the course of a vessel in making a voyage between well-known ports.

The candidate's knowledge of the geography of the United States can not be too full or specific on all the points referred to above. Accurate knowledge will also be required of the position of the country with reference to other States, and with reference to latitude and longitude, of the boundaries and relative position of the States and Territories, of the name and position of their capitals, and of other important cities and towns.

United States History.—The examination in this branch will include questions concerning the early settlements in this country; the forms of government in the colonies; the causes, leading events, and results of wars; and prominent events in the history of our government since its foundation.

World's History.—Candidates must be familiar with the general history of the world, including the rise and the fall of empires and of dynasties; changes in territory as the result of wars or from other causes; the most important treaties of peace; the relations between church and state in different countries; in brief, such information as may be found in the ordinary general histories.

Arithmetic.—The candidate will be required—

To express in figures any whole, decimal, or mixed number; to write in words any given number; to per-

form with facility and accuracy the various operations of addition, subtraction, multiplication, and division of whole numbers, whether abstract or compound, and to use with facility the tables of money, weights, and measures in common use, including English money.

To reduce compound numbers from one denomination to another, and to express them as decimals or fractions of a higher or lower denomination; to state the number of cubic inches in a gallon and the relation between the troy and avoirdupois pounds, and to reduce differences of time to differences of longitude and *vice versa*.

To define prime and composite numbers; to give the tests of divisibility by 3, 5, 7, 9, 11, 25, and 125; to resolve numbers into their prime factors, and to find the least common multiple and the greatest common divisor of large as well as small numbers.

To be familiar with all the processes of common and decimal fractions; to give clearly the reasons for such processes, and to be able to use the contracted methods of multiplication and division given in the ordinary text-books on arithmetic.

To define ratio and proportion, and to solve problems in simple and compound proportion.

To solve problems involving the measurement of rectangular surfaces and of solids; to find the square roots and the cube roots of numbers, and to solve simple problems under percentage, interest and discount.

The candidates are required to possess such a thorough understanding of all the fundamental operations of arithmetic as will enable them to apply the various principles to the solution of any complex problem that can be solved by the methods of arithmetic; in other

words, they must possess such a complete knowledge of arithmetic as will enable them to proceed at once to the higher branches of mathematics without further study of arithmetic.

Algebra.—The examination in algebra will include questions and problems upon the fundamental rules, factoring, greatest common divisor, least common multiple, algebraic fractions, equations of the first degree with one or more unknown quantities, simplification of expressions involving surds, and the solution and theory of quadratic equations.

Geometry.—In geometry candidates will be required to give accurate definitions of terms used in plane geometry, to demonstrate any proposition of plane geometry as given in the ordinary text-books, and to solve simple geometrical problems, either by a construction or by an application of algebra.

It will be observed that these examinations are considerably below the average requirement of engineering schools. No foreign language whatever is expected and no natural science. The examination papers themselves are, however, very thorough. It does not follow that graduates who succeed in passing them are well fitted to go on with the work, as several cramming schools have grown up for the preparation of young men to pass the Naval Academy examinations. In case a boy of fourteen or fifteen is told by a congressman that he is to have the appointment, he goes to Annapolis and there crams for a year, especially on those problems which are likely to be given by the examiners. The system is essentially a vicious one in this respect, and many boys are let loose upon the

streets of Annapolis without responsible guidance to get a superficial preparation for entrance to the school. West Point has changed its system of entrance examinations in order to admit cadets by certificate. The certificate of any reputable school whose course of instruction covers the subjects required for admission to the Military Academy is accepted. It would seem that a little modification of the Naval Academy entrance requirements might be advisable.

The object of admitting students in June is to give them practical instruction during the first summer. This practical instruction covers sail drill, ordnance, and steam machinery. The day is divided into five periods and the class is divided into four divisions. During the first period, from eight to ten, two divisions have drill in ordnance and two in sails; during the second period, from ten-fifteen to twelve-fifteen, the divisions change places; during the third period two divisions have exercises in steam launches and machine shops, and two in boats under oars or sails; during the fourth period from five to five-thirty, all divisions have swimming; during the fifth period, from eight to nine, all divisions have physical exercises, either in the gymnasium or armory. This work extends through the entire summer, during part of which there is some instruction given in modern languages. The intention is to give the midshipman a good practical introduction to his profession during his first three months in the school. It is found possible in steam engineering, for instance, to teach green country boys who have never seen a steam-engine how to run a steam-launch or a small torpedo boat, and to give them a practical knowl-

edge of every detail, from the tiller to the grate bars. At the end of the summer, a crew of midshipmen could be put on board a small torpedo boat with instruction to get up steam and get the boat under way. They are entirely able to handle the machinery and to direct the movements of the boat as a whole.

The serious study of the course begins at the opening of the academic year, and it seems worth while to give here in detail, taken from the register for 1903-1904 the course of instruction:

COURSE OF INSTRUCTION, 1903-1904.

(Reference books are marked*.)

First Year—Fourth Class.

First Term.

Departments.	Periods Each Week.	Subjects.	Text-books.
Marine engineering and naval con- struction	3	Mechanical draw- ing.	Bartlett's "Mechanical Drawing."
Mathematics	6	Algebra.	Hall & Knight's "Elemen- tary Algebra." Hall & Knight's "Higher Algebra."
		Logarithms, geom- etry, and de- scriptive geom- etry.	Gauss's "Tables of Loga- rithms."* Chauvenet's "Geometry." Church's "Descriptive Geometry."
English and law..	4	English.	Hill's "Foundations of Rhetoric." Hill's "Principles of Rhet- oric." Buehler's "Practical Exer- cises in English." Webster's "Dictionary."*
Modern languages.	3	French.	Marion's "Elementary Course of French Pronun- ciation." Berey's "Le Français Pra- tique." Berey's "La Langue Fran- çaise," I.

Second Term.

Departments.	Periods Each Week.	Subjects.	Text-books.
Marine engineering and naval construction	3	Mechanical drawing.	Bartlett's "Mechanical Drawing."
Mathematics	6	Algebra.	Hall & Knight's "Higher Algebra."
		Descriptive geometry; trigonometry.	Church's "Descriptive Geometry." Bowser's "Trigonometry." Gauss's "Tables of Logarithms."*
English and law..	4	English.	Genung's "Outlines of Rhetoric." Abbott's "How to Write Clearly." Maxwell & Smith's "Writing in English." Andrew's "Manual of the Constitution." Webster's "Dictionary."* Themes.
Modern languages.	3	French or Spanish.	Bercy's "La Langue Francaise," I., II. Marion's "Le Verbe." Bellow's "Dictionary." Marion and des Carrennes's "Introduction a la Lengua Castellana."

Second Year—Third Class.

First Term.

Marine engineering and naval construction	2	Mechanical drawing.	Bartlett's "Mechanical Drawing."
Physies and chemistry	2	Elementary physics.	Daniell's "Principles of Physies." Stewart & Gee's "Practical Physies."
		Chemistry.	Remsen's "Introduction to the Study of Chemistry." Lecture notes.
Mathematics	6	Trigonometry.	Bowser's "Trigonometry." Chauvenet's "Trigonometry." Gauss's "Tables of Logarithms."*

Departments.	Periods Each Week.	Subjects.	Text-books.
			Bowditch's "Useful Tables,"*
		Descriptive geometry and conic sections.	Church's "Descriptive Geometry,"
			Dresel's "Stereographic Projections."
English and law..	2	United States naval history.	Smith's "Conic Sections."
			Maclay's "History of the United States Navy."
			Webster's "Dictionary."*
Modern languages.	4	French or Spanish.	"Le Francais Pratique."
			"La Langue Française," I.
			Marion's "Le Verbe."
			Ybarra's "Practical Method."
			"Cuentos Castellanos."
			"Compendio de la Gramática de la Lengue Castellana."

Second Term.

Marine engineering and naval construction	2	Mechanical drawing.	Bartlett's "Mechanical Drawing."
Physics and chemistry	4	Elementary physics.	Daniell's "Principles of Physics."
			Stewart & Gee's "Practical Physics."
			Watson's "Physics."
		Chemistry.	Remsen's "Introduction to the Study of Chemistry."
			Stoddard's "Outline of Qualitative Analysis."
			Lecture notes.
Mathematics	7	Conic sections.	Smith's "Conic Sections."
		Differential calculus.	Rice & Johnson's "Differential Calculus."
		Integral calculus.	Johnson's "Integral Calculus."
English and law..	1	Naval history.	Maclay's "History of the United States Navy."
Modern languages.	4	French or Spanish.	"La Langue Française," II.
			Spanish comedy.
			Marion's "Le Verbe."
			"Gil Blas de Santillana."

Third Year—Second Class.
First Term.

Departments.	Periods Each Week.	Subjects.	Text-books.
Ordnance and gunnery.....	1	Infantry and artillery instructions.	Drill regulations.
Marine engineering and naval construction	3	Principles of mechanism.	Goodeve's "Elements of Mechanism."
	3	Mechanical processes.	Gow's "Notes and Problems." Lineham's "Mechanical Engineering."
Mechanics	5	Theoretical mechanics.	Johnson's "Mechanics."
Physics and chemistry	3	Physics.	Daniell's "Principles of Physics." Watson's "Physics." Stewart & Gee's "Practical Physics." Lecture notes.
		Chemistry.	Stoddard's "Outline of Qualitative Analysis."
Modern languages.	3	French or Spanish.	"La Langue Française," II. "Gil Blas."

Second Term.

Seamanship	2	Seamanship.	Knight's "Modern Seamanship."
Ordnance and gunnery.....	1	Infantry and artillery instructions.	Drill regulations.
Navigation	2	Astronomy.	White's "Astronomy." "Nautical Almanac."* Bowditch's "Navigator."*
Marine engineering and naval construction	4	Marine engines and boilers.	Sennett & Oram's "Marine Steam Engine." Marine engines, problems, notes, and sketches. Huntington & McMillan's "Metals."
Mechanics	3	Mechanics.	Cotterill & Slade's "Lessons in Applied Mechanics." Alger's "Hydro-Mechanics."
Physics and chemistry	4	Physics, electricity and magnetism.	Same as for first term. Thompson's "Electricity and Magnetism." Day's "Exercises in Electrical Measurements." Lecture notes.
Modern languages.	F	French or Spanish.	French and Spanish comedy and novels.

Fourth Year—First Class.
First Term.

Departments.	Periods Each Week.	Subjects.	Text-books.
Seamanship	2	Seamanship and naval tactics.	Knight's "Modern Seaman-ship." "Tactical Signal Book." Department Circulars.* Navy Regulations.* Hoff's "Elementary Naval Tactics."
Ordnance and gunnery.....	3	Gunnery drill. Guns and gun mounts.	Ingersoll's "Text-book of Ordnance and Gunnery." Drill regulations. Gun and torpedo drills. Clear ship for action. Naval Institute "Professional Notes."
Navigation	4	Navigation.	Coffin's "Navigation." Bowditch's "Navigator."* Azimuth tables.* "Nautical Almanac."*
Marine engineering and naval construction	2	Boilers.	Bertin & Robertson's "Boilers." Carpenter's "Experimental Engineering."
	2	Naval construction.	White's "Manual of Naval Architecture." Atwood's "Text-book of Theoretical Naval Architecture." Special notes and drawings. Navy Department pamphlets. Notes and problems. Same as for last term.
Physics and chemistry	3	Physics.	Thompson's "Dynamo Electric Machinery and Lecture Notes."
Modern languages.	F	French or Spanish.	French and Spanish comedy and novels.

There will be a course of lectures on physiology and hygiene during the first term of first class year. One period will be taken for this purpose from each of the departments, ordnance and gunnery, navigation, marine

engineering and naval construction, and physics and chemistry.

The time is measured in periods per week. The table of coefficients is based upon a maximum mark of 4. Values are fixed for the various subjects and a student's record is made up by multiplying his marks by the respective values allotted to the subjects and then adding together the results. The minimum passing mark is 2.5.

TABLE OF COEFFICIENTS, 1903-1904.

Departments and Subjects.	Fourth Class.	Third Class.	Second Class.	First Class.	Maxima for Four Years.
Conduct and practice cruise.....					104
Conduct	2	3	4	$2\frac{1}{2}$	
Efficiency	1	2	4	$2\frac{1}{2}$	
Practice cruise				5	
Seamanship					36
Steamship and naval tactics.....			5	4	
Ordnance			5	7	48
Navigation			5	9	56
Marine engineering and naval construction.....					108
Principles of mechanism and marine engines and boilers			9		
Mechanical processes			3		
Boilers				3	
Engineering materials and designing.....				3	
Naval construction				2	
Mechanical drawing	3	4			
Physics and chemistry.....		7	9	6	88
Mechanics			12		48
Mathematics	6	12			72
English and law.....	4	4			32
Modern languages	3	8	4		60
Physiology and hygiene	1				4
Total	20	40	60	44	656

PROGRAM OF RECITATIONS, 1903-1904.
FIRST TERM.

Departments.	Fourth Class.	Third Class.	Second Class.	First Class.	Total.
Seamanship .....	.....	.....	.....	Tu. (3), F. (3) ..	2
Ordnance and gunnery.....	.....	.....	Th. (2)	M. (1), W. (1), F. (2)	4
Navigation .....	.....	.....	.....	W. (3), Th. (1), F. (1), S. (1) ..	4
Marine engineering and naval construction	Tu., W., F. (3) ..	M. (1), Th. (3) ..	M. (3), Tu. (1), W. (1), Th. (1)	M. (2), Tu. (2), W. (2), Th. (3) F. (2)	13
Mechanics .....	.....	.....	M. (2), Tu. (2), W. (2), Th. (3), M. (1), Tu. (3), F. (1) .....	.....	5
Physics and chemistry.....	.....	W. (3), Th. (1) ..	.....	M. (3), Tu. (1), Th. (2)	8
Mathematics	M., Tu., W., Th., F., S. (1).....	M., Tu., W., Th., F. (2), F. (3) ..	.....	.....	12
English and law	M. (3), W. (2), Th. (3), F. (2)	Tu. (1), S. (1) ..	.....	.....	6
Modern languages	M. (2), Tu. (2), Th. (2)	M. (3), Tu. (3), W. (1), F. (1) ..	W. (3), F. (3), S. (1) .....	.....	10
Total first term.....	.....	.....	.....	.....	64

PROGRAM OF RECITATIONS, 1903-1904.
SECOND TERM.

Departments.	Fourth Class.	Third Class.	Second Class.	First Class.	Total.
Seamanship .....	.....	.....	Tu. (3), F. (3) ..	.....	2
Ordnance .....	.....	.....	M. (3) .....	.....	1
Navigation .....	.....	.....	M. (2), S. (1) ..	.....	2
Engineering	Tu., W., F. (3) ..	M. (3), Th. (3) ..	Tu. (1), W. (2), Th. (1), F. (2)	Graduated	9
Mechanics .....	.....	.....	Tu. (2), W. (1), Th. (2) .....	.....	3
Physics .....	.....	Tu. (1), W. (1), Th. (1), F. (3)	M. (1), W. (3), Th. (3), F. (1)	.....	8
Mathematics	M., Tu., W., Th., F., S. (1)	M., Tu., W., Th., F. (2) .....	.....	.....	11
English	M. (2), W. (2), Th. (3), F. (2)	S. (1) .....	.....	.....	5
Languages	M. (3), Tu. (2), Th. (2)	M. (1), Tu. (3), W. (3), F. (1) ..	.....	.....	7
Total second term.....	.....	.....	.....	.....	48
Total 1st and 2d terms...	.....	.....	.....	.....	112

During the school year the day is divided into periods, and midshipmen find themselves under direction from the time they get up in the morning until they go to bed at night. The numbers in brackets under the program of recitations indicate periods; (1) being from 8 to 10 A.M., (2) being from 10:15 to 12:15 and (3) being from 2 to 4. The afternoon, between four o'clock and supper, is given mainly to drill. The evening, after supper, is devoted to study, during which time midshipmen are required to keep their rooms. The classes are divided into sections, averaging ten or twelve members each; every month the sections are arranged according to standing in the various subjects. The first section includes the ten or twelve men who have had the best record during the previous month; the second section, the next grade of men; and so on down to what is in the Naval Academy phrase the "wooden section." Every midshipman has the opportunity to recite every day—not from a lecture which has been previously given, but from an assigned lesson in a text-book. The instructors in non-professional subjects have as their main duty to listen to recitations.

The positions held by civilians are not specially attractive, although the salaries are about equal to those of the average college, perhaps slightly below. There is not the academic freedom or elasticity that would be found in a college, inasmuch as everything must be fitted into a cast-iron system that has grown fixed and unchangeable during the two generations of the existence of the Naval Academy. Furthermore, there is no incentive for study and research by civilians. Their duties are mainly clerical, that is to mark students upon

what they have studied out for themselves. In languages, both native and foreign, there is of course necessarily some instruction, but that is very limited. French and Spanish are well taught by means of the phonograph. Midshipmen are expected to understand the languages as well as to read them. Another side to the Naval Academy is that a civilian must necessarily feel himself, as he is, the adjunct to a professional course, in which the officers have great experience and stimulus. They return to the Naval Academy after a tour of duty lasting three years with everything fresh in their minds, having come in contact with other officers whose duties do not lie in the direction of teaching. For this reason, the professional instruction is something more than listening to recitations, as it consists in practical exercises of all kinds in addition to study. There is still another element in connection with the teaching of professional subjects; that is, that many of the instructors are men who have distinguished themselves in service, as during the past six years the Naval Academy has had many of the officers who were in the Spanish War. Wainwright was superintendent and many of his colleagues were men well known to the midshipmen as well as to the country. The course is necessarily by its nature narrowing, but the same thing may be said of most schools which teach a profession. The same thing has been said of law, of medicine, and of technical schools giving engineering degrees. I am persuaded, however, that a naval training is of necessity more narrowing than others on account of the fact that the men are taught a profession entirely outside of the ordinary, in which they are somewhat removed

from the common walks of life. It has always seemed therefore that the Naval Academy would profit by contact with civilian institutions and that some of the non-professional instruction ought to be given by men called in from the outside. A few courses of lectures, each extending over a few weeks, could not fail to be stimulating to officers as well as to students. These could be extended even to professional subjects, such as steam engineering and electrical engineering. Physics and chemistry would be fruitful fields for outside men. It has never, however, been the policy of the Navy Department or of the school to make room in the course of instruction for outsiders to deliver lectures. At the same time a useful reform might be effected by a small change in policy.

One of the most important features of the course is the summer practice cruise. The midshipmen start from Annapolis early in June for three months at sea where they are thoroughly drilled in all the practical details of their profession. They are usually sent in several vessels. One of these, the *Chesapeake*, is exclusively for sail drill and the others are steamers. Visits are made to the Atlantic seaports, where the larger shops and manufactures are inspected. At the end of the practice cruise, all midshipmen are allowed one month's vacation. It will be seen that the course is thus eleven months every year, instead of only nine. The additional time is, however, devoted entirely to practical exercises.

The equipment for laboratories at the Naval Academy is superior in quantity to that of any civil school, because the government is behind it. Expense is not

spared, and, if we reckon the practice cruise vessels as part of the total equipment, the amount runs into the millions. The shops are fitted with the ordinary machine tools in such number that large classes can be taken at the same time. While small sections and many instructors are the rule in class-room work, large sections and numerous tools prevail in the laboratories. The draughting room is so extensively equipped that a class of three hundred, the entire first-year class, receive their instruction during the same hours. The draughting tables and laboratory apparatus thus lie idle a larger percentage of the time than could be afforded in a civil institution.

Another difference is that equipment in a civil school is used as much as possible to promote science and its application: at the Naval Academy it is rarely used for anything but instruction. The new laboratories, including the armory, boat house, steam building and science building, will add greatly to the facilities for instruction. In fact, the whole Naval Academy is to be rebuilt in the course of the next few years.

Another side to the school is the close surveillance upon the students. The grounds are surrounded by a brick wall with only a few gates over which marines stand guard and the dormitories are arranged so that they can be readily inspected night and morning by officers in charge. Every room is open at all times for examination, and everything in the room has a place allotted to it by order of the commandant. Midshipmen are thus forced to learn system as part of their preparation for shipboard life.

To summarize the place of the Naval Academy

among the institutions for the technical education of men, certain points may be noted. It should be remarked here that the school is as much an engineering school as any of the great college departments or the separate technical schools. The curriculum contains as large a percentage of engineering instruction as any other school, and it has a much larger percentage of practicing instruction.

1. The entrance examinations are below the standard of most colleges and technical schools. The standard is kept down for the sake of those congressional districts where opportunities for education are not great.

2. The total amount of class-room and book work for graduation is below that of technical schools, although the practical exercises cover more time than at most schools.

3. The control and regulation of the student's life extends to the smallest details, thus tending to take away initiative in beginning or originating work not ordered.

4. The education is somewhat narrow.

As against these objections to the course there are the following advantages:

1. The sections are small and the individual attention is greater than that of any civil school in the country. This follows necessarily from the fact that there are a much larger number of instructors than any privately endowed school could possibly afford.

2. The sections are arranged according to relative standing of the students, so that the brighter men are not burdened with the inefficient. There is the stimulus of minds equal in capacity, and those who are not

able to carry the work are relegated to a place from which they do not ordinarily recover.

3. By far the greater part of the instruction is from text-books and notes, which students must dig out for themselves, acquiring thus great independence and initiative in attacking any problem definitely set before them.

4. The practice cruises every summer, and the drills every afternoon, give students an intimate acquaintance with their profession, to be found elsewhere only in medical schools having a four years' course.

5. The expense of instruction or of laboratory machinery are not to be considered, as the government pays the bills. There is difficulty sometimes in obtaining appropriations from Congress, but as a rule the Naval Academy has obtained what is wanted. Recently Congress has appropriated ten millions of dollars to rebuild the school.

6. Students are held to a strict responsibility for their conduct and their scholarship; excuses are not accepted unless they are real. Sickness forms no excuse whatever for deficiency in studies. It is this discipline which probably promotes effectiveness in all kinds of academic work.

7. There is after graduation a commission for every one who successfully passes examinations and whose record demonstrates his capacity to make a good officer. It is this definite end in view, together with the certainty of a life position, which is a tremendous spur to every student.

8. At present there is absolutely no cheating at the Naval Academy, and the students can not get help of

any kind from tutors. While they may get some instruction from one another in preparation for recitations and examinations, it seems hardly possible for anyone to get through excepting upon his own work.

DISCUSSION.

THE PRESIDENT: This paper can be better appreciated if it be stated that in addition to having occupied a chair of engineering at Harvard University for a number of years, Professor Hollis is a graduate of the Naval Academy, and served for a considerable time as an engineer in the navy. He is therefore able to take the point of view of the practitioner as well as teacher.

PROFESSOR HATT: The speaker is in accord with Professor Hollis's very interesting and suggestive paper. The speaker, however, does not believe that the system adopted at the Naval Academy, in which the students of various grades of preparation and natural ability are placed in different sections, is a good system, both from the standpoint of the progress of the students as a whole and from the practical standpoint of the relations of the subjects of the curriculum.

It has been the speaker's experience that when a number of students, either poorly prepared or of poor natural abilities, are placed together in a section, they become dispirited, and the distance between the sections of poorer students and sections of better students becomes greater. The poorer or duller students are benefited by contact with their brighter brothers in the class-room.

The curricula of most of our colleges are arranged according to a system whereby one stage becomes pre-

paratory to another. The teacher of mechanics prepares the men entrusted to him for the applied work of machine design. It would seem a better plan to send a homogeneous product to this applied work.

There is certainly a spirit reigning in the class-room which must be counted upon since we are dealing with human beings. The speaker envies neither the students nor the instructor in what has been called "a wooden section."

THE PRESIDENT: There is opportunity for differences of opinion on that point. I am inclined to believe a teacher can do better work in a small section with men whose speed and capacity are about equal, that more time can thus be given the slower section so that the work of the teacher will be somewhat better if the sections are graded. That the men should have an opportunity to be in contact with each other in the work to a greater or less extent is good. But previous to hearing this paper and independently of it I have recently been disposed to favor the grading of sections, if it can be arranged. I am still inclined to differ with Professor Hatt on that point.

PROFESSOR JOHNSON: Some can not learn and others will not. Both these classes I prefer to keep by themselves. The way we are situated at Cambridge, when we find a student is not headed right, we try to turn him into some of the other lines of work offered by the university: and the earlier this can be done the better. We think such a course is better for the profession than to try to nurse along the misfits.

THE PRESIDENT: It is a benefit to the profession and a benefit to the men.

PROFESSOR JOHNSON: I think under such conditions one of the most important parts of my duty is to suggest other lines of activity.

PROFESSOR JACOBY: There is one important service that those who have charge of students in mechanics can render, which will be appreciated, and that is to weed out at as early a stage as it can fairly be done those who ought not to go ahead. Of course there are some benefits to be derived by weak students being placed with those who are stronger, but it seems that there is a tendency on the part of poor students to impose on good students, not simply to gain their help, but to get them do a part of the work which they ought to do themselves, and thereby hinder their own development. Therefore the method described in the paper has much to commend it.

PROFESSOR JOHNSON: The policy of Harvard has been steadily to raise the entrance requirements, until for admission to the Scientific School the requirements are of the same grade as for entrance to Harvard College. What I regard as the normal outcome of this whole thing is that it will be seen that the most advisable course for a young man to pursue is to enter Harvard College. The requirements are not any higher than those for the Scientific School, except that for the college he has to have Latin. Having entered Harvard College, in three years he can get the degree of A.B. and during that time he can take a considerable amount of engineering work. At the end of these three years, he should really know whether he wants to study engineering, and whether he is competent to study it. Then in two years from his completion of the A.B.

course he will be ready for the bachelor's degree in engineering. I noticed by the last commencement program that of the thirteen graduates in my own department (civil engineering) nine, or about 70 per cent. had previously received a degree of A.B. or S. B.

PROFESSOR S. N. WILLIAMS: I understand from this paper, and from my previous knowledge, that at Annapolis and West Point they do not make the same requirements for admission that we make in technical schools in our own state. We are undertaking to hold closely to the requirement of four years' high school work as an admission to the engineering courses, and the question arises in my mind whether the thoroughness of the instruction there given, and the personal attention by the instructors to the students, compensate to a very large extent for the lack of a more complete preparation for admission. Another question is whether we are requiring too much in insisting on four years' high school preparation for admission to technical schools, or whether the government should insist on larger preparation for admission to the military and naval schools. I would like to inquire how long the government has accepted certificates for admission to West Point. I supposed as heretofore that a rigid examination was required on the subjects demanded for admission.

PROFESSOR WALDO: The last word has hardly been said about mixing the good and bad men together, or keeping them separate, in the sense that those who are able are good and those who are not able are bad. The two ideas, mixing and separating, are certainly opposed, and we find them struggling for expression in a good

many more ways perhaps than we at first think of. We have an aristocracy in society and a democracy in society. We have an aristocracy in education, and a democracy in education. The institution which is dependent for its support directly upon the common school, and is at the head of the public school system of a state, must use the democratic method of arranging its classes. The institution that stands on its own foundation may have aristocratic educational ideas, and may work for the exceptional few. There is a question, and a very large one, as to whether we are doing the best thing for our country by segregating the bright men from those that, at one period of their development, seemed to be dull—and were dull. I think it is the experience of every teacher that there is a great difference in the period of the maturing of different students. You take a certain class of students, and they are dull, perhaps, when they come to college. They have not yet reached that maturity when they acquire knowledge rapidly and easily, and men of that class will be prejudged and thrown out of an institution, and you hear nothing more from them, and very likely you have lost in so doing a great many men who would have been valuable men in the intellectual world. It is my experience that some of the very best fellows I have ever had anything to do with would have been thrown out just that way; and if they had been relegated to the “ wooden ” section, such as we have been talking about, they would have disappeared from the school, and never have been heard from again. And yet I can follow the history of some of those fellows, and note their success in after life, and I can tell you

some of them are the very best and brightest men in the communities where they now live. And they would have been nothing but blacksmiths and plain artisans had the other course been pursued. I believe the question of segregating or of mixing bright and poor students is a very important one and can not be settled by the practice of Annapolis or West Point.

PROFESSOR A. N. TALBOT: This discussion on segregation of students would be cleared up by cutting out the expressions concerning two classes of students mentioned—the “ wooden ” student and the student not well prepared for going on with his work. I believe we are agreed that these two classes of students should not be admitted to regular classes. Certainly the “ wooden ” student has no place there; and the man who is not prepared should make his preparation and come in later. When we exclude these it is my feeling, from my own experience in teaching, that there is an advantage in mixing students in general class work. The good student gets something from the poorer student. It is not all of education to learn technical things. The student should learn human nature as well, learn to read his fellow student. The dull student certainly is greatly benefited by contact with the brighter mind. With the exception of a course or two, like thermodynamics and similar topics, when it may be well to put the bright students by themselves in order to develop keenness and to go deeper into the subject, there must be an advantage to students to be mixed in classes.

PROFESSOR MAURER: It seems to me that the relations between school and student at the national academies

are unique; thus Uncle Sam actually pays young men a stated sum for the privilege of training and testing them for his service. Therefore he may feel entirely free to select and reject and to employ any reasonable method for the sorting. The method just explained to us strikes me as appropriate and effective.

The purpose of the colleges here represented is different from that of Annapolis. As I conceive it, that purpose is service to many rather than to few; their function is to educate rather than to sort students. I believe that the Annapolis plan of segregation is not appropriate in these colleges. I am uncertain as to the exact practice which we should follow in weeding out poor students. Although I wish we might be as strict as Uncle Sam, I feel that we must pursue a more moderate course and that especially we of the colleges maintained by the public must bear in mind the motto: "The greatest good to the greatest number."

PROFESSOR SPERR: I do not think it necessarily follows that the men are weeded out by putting them into the "wooden" section. Their not being able to keep up with the men who are better prepared, may mean that they only require more time, and may have to repeat the subject. I have followed both practices, and I am not yet satisfied which is best. I have found that the poorer men are liable to fail to understand what the subject really means, and think that if they can simply pass the examination by the help they can receive from the abler students, they have attained all that is necessary. I think we should see to it that whatever they acquire, they must acquire in such a manner that it shall be their own.

Another thought which interested me in this paper was that of specialization, remembering that the report of the Committee on Requirements for Graduation advised against this. It appears to me that specialization to some extent can hardly be avoided in an engineering school.

PROFESSOR HOLLIS (by letter): It was a matter of regret that I could not be in St. Louis for the meeting of the Society. In reference to the several questions raised during the meeting, I would supplement Professor Johnson's answers as follows:

Some attempt has been made at Harvard in my own classes to follow the Naval Academy system, but it has seemed so contrary to the usual methods of the university that the attempt is necessarily confined to one or two subjects. In applied mechanics I have divided the class into two groups: those whose previous records demonstrate that they have fitness for mathematical work and for general engineering training, and those whose previous records show that they are weak in mathematics. The first group is placed in a section which meets three hours a week, the second group in a section which meets five hours a week; thus giving the weaker men more of a drill. It has worked exceptionally well for the first named section, but not especially well for the second section. In fact I have serious doubts if it is well to take men who are weak in mathematics and by any system to endeavor to train them for general engineering work. Many of them may have ability in the direction of the business side of engineering, such as directing the work of laborers in the field and carrying out contracts on engineering con-

struction; but for the scientific side of engineering it seems to me very doubtful if men mentally unsuited to the profession ought to be encouraged to obtain a degree.

However, the two-section method has worked well enough here to be called successful. Our chief difficulty is, at times, a lack of money to pay instructors for the sections, as that system undoubtedly calls for a larger appropriation.

In reference to the question asked by Professor Turneure, I do not think that the Naval Academy insists strenuously on originality. The main question is one of accuracy, not only in the results obtained in the classroom, but in the forms and methods pursued to obtain those results. For instance, when I was in the school we customarily had on Saturday morning an hour examination in mathematics. While we were studying trigonometry, this examination consisted of five spherical triangles to solve and check within the hour. It has always seemed to me that such an examination presents a fine training in accuracy and in readiness to do the work presented. College boys are, as a rule, inaccurate in their mathematics, especially in their arithmetic, and I believe a weekly examination extending through the entire year would be an excellent addition to the system of any scientific school. The examination approaches more nearly the conditions of work subsequent to graduation than anything else can, as it places the student under a certain kind of emergency.

In regard to the use of text-books, I did not find them simply methods of memorizing, as all the problems given in the weekly examination were original.

Furthermore, the text-books had great numbers of problems in them, in which the cadets had little or no assistance. The solution of problems can not be called a method of memorizing, and a student who has studied a text-book sufficiently to be able to solve the problems given in the book, has accomplished something more than simply to memorize the text. It has always seemed to me that the arrangement of classes in sections, and the use of text-books which the students are to study out for themselves, forms a general basis of an effective school. At the same time, the system if followed too far becomes cast-iron, and I think it should be supplemented by lectures and outside reading in the ordinary college or scientific course.

REPORT OF COMMITTEE ON TECHNICAL BOOKS FOR LIBRARIES

Your Committee on Technical Books for Public Libraries reported at the last meeting of this Society upon the work which it had done up to that time. The report covered a period of two years and included the presentation of a classified list of books and publications suitable for general library purposes. During the past year this committee, the appointment of which was extended for another twelve months, has made no attempt to revise or to enlarge this list, so that the present report can deal only with the manner in which this list was received by those whom it was intended to serve, while it also discusses the advisability of carrying the work still farther.

Several hundred copies of the list have been printed and furnished free to librarians and others who have been interested in the matter. The distribution has not been very general as the number of copies available was not sufficient to make a wide circulation possible.

The question which naturally comes up for consideration is as to whether the work of the Society through this committee shall be regarded as completed or whether it is advisable to continue it further. If the former view is held, the list of books will soon lose its value, since its usefulness will decrease with every valuable contribution made to scientific and technical literature in the future. If, on the contrary, it may appear to this Society that the importance of the work justifies it, the list should be extended to include cer-

tain additional lines of technology and should be revised each year, new works of merit being added or those now listed being superseded by better or later ones.

If the enthusiasm shown in the reception of the list already prepared can furnish sufficient justification for the adoption of this course, there should be no hesitation about continuing the work. A large number of requests for copies had been on file before the publication of the list, showing the demand that already existed, and the demand is increasing as more people come to know that such a list has been compiled. The various acknowledgments which the chairman has received from those to whom the list was sent make it evident that its value is fully appreciated. In almost every case those who received and made use of it in ordering books wrote enthusiastically of the assistance which it gave them and commended the work of the committee most favorably.

To the question as to what benefit will come to our Society if some of its energies are expended in this line of work, it may be said that the very name of the Society implies an obligation to give all possible assistance to those wishing to avail themselves of the best technical literature. If such a list could be revised from year to year and given wide circulation, the Society and the purpose for which it stands would become better known and its influence would steadily increase as its authority becomes recognized not only by librarians and those who use technical books, but also by the publishers and authors.

Due consideration should be given to the magnitude of such an undertaking, yet it does not appear to your

committee that the labor involved would be a serious drawback to its adoption, provided it could be systematically carried on. By far the hardest part of the task has already been accomplished in the compilation of the original list, and the annual revision would necessitate only a review of the year's books for the purpose of estimating their suitability for a place on the list. It is suggested that for this work a standing committee be appointed, such committee to be representative of the various lines of science and technology. It seems desirable, also, that the Secretary of this Society should act as secretary of this committee, thereby making it easier for librarians, publishers and others to communicate with the committee. If it shall be decided to issue such an annual list this should be published in pamphlet form, separate from the bound volumes of our transactions, copies being furnished from the office of the Secretary.

C. F. BURGESS,
Chairman, for the Committee.

THE PREPARATION OF ENGINEERING TEXT-BOOKS.

BY EMERY H. POWELL,

Engineering Text-book Writer International Correspondence Schools.

The subject matter is the important part of a text-book. It should be first simple in treatment, then clear in expression, and finally practical in application. The external appearance, style of binding, grade of paper, size of type, and quality of illustration all enter into a book and have much to do with its attractiveness and usefulness. A proper combination of good quality in these respects does much to place any book in a position to receive favorable consideration. In spite of all that the best of externals can do, however, they can not cover up defects in the subject matter of a text-book, especially when it is put to the final test of actual class use.

There are two very important principles that should predominate in preparing the subject matter. First, every idea and thought essential to the clear presentation of the subject should occupy its logical position; second, the language should be such as to express the thought correctly and in such a manner that it can not be easily misunderstood or misconstrued. Many writers of technical literature seem to find it difficult to comprehend the position the reader or the student occupies with relation to the subject treated. Consequently, they are unable to begin at such a point and in such a manner that the student will grasp the elementary con-

ception of the subject. Others find it difficult to take up the ideas in their natural, or even in a simple, order, getting ideas from one part confused with ideas from another, and while having a very satisfactory knowledge of the subject themselves, they give to the student the impression of a disjointed compilation of statements relating to the subject. The logical arrangement of the text seems to be one of the most difficult matters for new writers to accomplish. Whether it is an inherent fault in the mental habits of writers or whether it is simply a lack of practice in writing seems impossible to determine, but it is likely that both enter into the difficulty to a considerable extent.

The second point, that of making statements or avoiding expressions that may be misunderstood or that can be misinterpreted, is one that receives too little attention by technical writers. Too often the writer's idea is to use choice language, sometimes to use large words, and at other times to express all the ideas possible in a single sentence. The habit of going over what has been written to see what impressions are possible as well as what are probable is of great assistance in ferreting out and correcting obscure or difficult passages.

Not so very long ago the *American Machinist* published some samples of the manuscript received by them from outside writers, and in a parallel column the edited text of the same matter. They were thus easily compared and some comparisons were quite ludicrous, while all were highly instructive. Our engineering text-books are better in both arrangement and expression than much of our other technical literature.

The field of engineering literature is as broad as the profession and the demand for good writers is increasing. The work of preparing engineering text-books as well as that of writing the best of the current technical literature must be done by educated engineers. One of the first and most important qualifications of such a writer is a technical education; another is practical experience in some one line. For some classes of writing, practical experience in one line gives a writer the breadth of view necessary for writing on a variety of subjects. In other classes of writing actual experience in the particular line of the subject is a first essential, but a technical education is almost equally necessary when it comes to giving the matter its final written form. A certain mastery of the subject is very necessary in preparing a text-book, not merely a complete understanding of the subject, but an absolute mastery, so that the writer may guide the student through its technical mysteries.

In order that a text-book shall be successful, also, it must be prepared for the specific field in which it is to be used. When prepared to satisfy one set of conditions and to meet the need for any one standard of preparation it may not be suitable where another set of conditions and a different standard of preparation prevail. A text-book suitable for our best engineering schools and colleges would manifestly not be suitable for evening classes or for men who must acquire their training through home study. The text-book should in each case be prepared for its own specific field. No doubt the attention of most of the members of this Society has been called to the marvelous success of

the International Correspondence Schools, in which text-books written especially for their field have been used from the beginning. The success of this school is no doubt largely due to the care with which the text-books have been prepared. The work of preparing text-books as carried on by the International Text-book Company, the proprietors of the International Correspondence Schools, is very complete and although devoted to the preparation of books for special classes of students studying under a new system, yet the books are of sufficient merit, I believe, to warrant a description of the method by which they are produced.

The business of the International Text-book Company is divided into a number of different departments somewhat as follows: General business, advertising, soliciting, accounting, instruction, stenographic, recording, text-book, illustrating, printing, etc. The text-book department has to do directly with the preparation of the text-books, although other departments assist more or less in this work. A number of the departments may contribute in the regular line of their work. The illustrating department makes drawings from sketches and photographs furnished by the text-book department. The stenographic department furnishes stenographers to take dictation and do typewriting. The instruction department, however, assists in an entirely different way; there the instructors make notes of questions asked by the students and a copy of the letters written by instructors in answer to questions of students is kept on file. Mimeograph explanations have been made covering points of instruction that were not made clear enough for some students by the instruc-

tion paper. These, together with the instructors' experience in teaching the correspondence student, are available to the writer in the work of preparing and revising text-books.

The work of revising the text-books is practically continuous and is, therefore, quite a large part of the work of the text-book department. This constant revision is one of the great reasons why these books are better suited to their field than any other books written. The books go into the hands of hundreds of students and others who are continually writing to the schools, either answering examination questions on these books or asking for further explanation. The author and student are thus brought into close contact and the author is able to make the revision suit the need of the student. Whenever it becomes apparent that any instruction paper can be improved and made more valuable and helpful to the student, it is revised. No expense is spared to make these books suit the field of their work.

The text-books for instruction by correspondence must be unique in order to be successful. The books must be simply and clearly written; advancing from the easy to the more difficult very gradually so that no statement shall be made that is not perfectly clear and that does not carry with it the evidence of why it is made. Any statements that are not clear become a source of continual expense, because the students will write repeatedly for information on every such statement. It is a great deal more expensive to explain a thing to several different students by a separately dictated and typewritten letter than it is to write the matter clearly for the text-book in the first place. The

preparation and mailing of mimeograph helps is an added expense, but has to be done when enough students show by their questions that the text is not clear to them. The idea is not to cheapen the course, but to avoid unnecessary expense, and as every student is given a courteous answer by a specialist to every reasonable question he asks, it is important to reduce the number of questions that the dullest student will ask. Hence, the text-book writer must determine as best he can what questions are going to be asked by the dull student when studying the instruction paper. The text must then be prepared so as to answer these questions and avoid raising others in the student's mind till the time comes to answer them. This work is one of the difficult parts of preparing text-books for teaching by correspondence.

The text-books, therefore, require very careful work by one who is well educated and has practical experience in the line about which he is writing, as well as experience in writing for this special class of students. It is said that it requires two years to develop, in a technical graduate of some years' practical experience, the comprehension or grasp of the situation, sufficiently to make a fairly good text-book writer. It will be seen, therefore, that this text-book work can not be done at small expense.

The International Text-book Company recently published a statement that the electrical engineering course cost \$42,000 to write, illustrate, and edit alone, not including printing or binding.

The subject matter of any of the courses of this school is separated into its natural divisions, which are

subdivided as much as necessary so that when written and printed, lessons of from thirty to forty or even fifty pages may be bound in pamphlet form. These lessons, or *instruction papers*, as they are called, are designed to be complete in themselves; in some cases a long subject may be divided into several parts and these are called Part I., II., etc., as for example, Machine Design, Part I., Machine Design, Part II. It is found to be very much less discouraging to the average correspondence student to have lessons of about thirty to forty pages rather than to have longer lessons. Such a division has both advantages and disadvantages for the writer; he must often discriminate very closely between the subject matter of the different parts. Sometimes two or three subjects that can be treated in a concise manner are combined to form one *instruction paper*, with the advantage to the writer that he is working on a small portion at one time and hence, can see the whole treatment of that instruction paper to better advantage. The *bound volumes*, as they are called, are the real text-books, and they are simply made up of the instruction papers bound together for preservation by the student. Each student receives the first two instruction papers of his course upon his enrollment as a student. When he answers the questions on the first paper he has the second to work with while his answers are being corrected. Other instruction papers are sent him, one at a time, when the corrections to his work are returned to the student. In this way he always has an instruction paper on hand to work with, as all papers are corrected in two or three days after being received at the main office. Furthermore, when

he has made certain payments on his course he is given a set of the bound volumes of his course to be used as a reference library.

There are two general methods of procedure in writing the lesson papers for a certain subject. In one the work is done by an outside writer, who has made a specialty or life work of that particular line. The manuscript is submitted to the department for which it was written and when accepted is edited and put in shape for the printer by the text-book writer. In the second the writing is done by some text-book writer already somewhat familiar with the subject, who looks up the available authorities and spends considerable time reading, studying, and thinking over the subject before writing. After the writing is finished it is type-written and copies sent to a number of outside specialists who have had large practical experience in that line, to be read and criticised by them. The matter with the suggestions and criticisms is gone over again by the author to incorporate the suggestions of the experts and to make other changes and improvements that may have presented themselves in the meantime.

When the text is edited by either process, the sketches and text go to the illustrating department, where the illustrations are prepared. The matter then goes through the copy-preparing department to the printing department. The work of the copy-preparing department is to go over all manuscript for grammatical errors and misspelled words and to mark the kind and size of type to be used by the printer. When the copy-preparers have finished putting their red-ink marks on a manuscript it is not necessary for the printer to think

about the size of type or the kind of headings; he simply sets the type according to the red ink directions. This department was originated by the International Text-book Company for the purpose of having expert supervision of the typographical work of their books. It is also considered to be a saving as this department can decide what size and kinds of headings and type should be used to better advantage than the printer. When the type is set up a galley proof is printed which goes to the regular proof-readers and then to the text-book writer for final reading. If the matter is found correct it is then paged and a page proof is printed and proof-read. If this is satisfactory, plates are made and the entire edition is printed and bound. Before the books are completed the proof has been read times enough to be as nearly sure as possible that there are no typographical errors.

From the experience of the text-book writers that I have met it seems very desirable that a number of men should be associated in the production of a text-book. Many of our present text-books have been written by individual writers and where the writers are strong the books reflect their strength. The individual characteristics of a writer often manifest themselves in a very clear and striking manner in his writings. In preparing a text-book he is likely to look at the subject from an individual standpoint; taking great pains to explain the points that were difficult for him to understand when he studied the subject and passing lightly over those that were easy. If the ideas of a number of men can be brought to bear on the preparation of the book, there is a strong probability that much of the

matter showing the peculiarities of individuals will be so modified as to leave only the good. To attain such a result would require considerable labor and it is a question whether it is practical to expect a number of men to be closely associated in the preparation of a text-book. Apparently the only way this is likely to be accomplished is by means of correspondence, but there are many reasons why even that method will not be employed. If a member of this association were preparing a text-book and there were ten or a dozen other members teaching in that same branch it would be a great benefit to the author and to the book to have the other ten or a dozen professors read and criticise the book. However, there are few men who are willing to spend the time and do the work of reading carefully and criticising a manuscript of a book when there is no remuneration and few of those preparing text-books care to spend much money for that for which they may get no return.

If this association would undertake to bring writers and the best critics together it would need an endowment fund to begin the work. Nevertheless such an arrangement is needed now more than ever before, because the profession is opening up more lines for specialization. The technical school must follow the leaders in the profession and the text-books are gradually becoming more specialized. There seem to be books enough to-day but to-morrow a new book will come into existence and it will soon fill a field entirely its own. More books of all kinds are being written to-day than ever before and the saying, "Of the making of many books there is no end," was never truer than

now. The engineering profession changes so rapidly that the problems of ten years ago have given place to others. The text-books will change more or less also, and so in a measure keep step with the advancement of the profession. The problem is, "What can we do to make the text-books of the future all they should be?" As has already been noted, simplicity and clearness are the lines which need attention and this can best be accomplished by the collaboration of a number of men who actually work or teach in the line the book covers.

One other point I should like to make is, that the practical application of the problems studied in any text-book does more to stimulate the interest of a student in his studies than almost anything else. For example, if the student is led to see that the inertia effect of the reciprocating parts of a steam-engine is of importance in designing the fly-wheel of the engine he will take a new interest in inertia. If he knows that entropy enters into the calculation of the quality of steam, he will be more apt to get a working knowledge of that "ghostly" quantity, as Professor Perry calls it, than he otherwise would. One reason why the correspondence schools have had such a phenomenal growth is that they have attempted to help men solve the problems of their every-day work and are educating them while doing so. If a text-book could be written so as to arouse the interest and hold the attention of the student, the labor of teaching would be greatly lessened, more people would study and their studying would be of more value. Simplicity of treatment, clearness of expression, and the evidence of the relation of his work

to the real engineering problems of the day are then three of the guiding stars for the text-book writer in preparing an engineering text-book.

DISCUSSION.

PROFESSOR J. P. JACKSON: The International Correspondence Schools have taught a lesson to the technical men of the country on the question of writing text-books. To a very large extent, as the author of this paper says, the great success of these schools has been due to their excellent set of books, on a varied line of subjects, and on which they have spared no expense.

The point with reference to what is sometimes called the relation between "practice" and "theory" is one which is neglected to a very large extent by the engineering profession. Some books treat of practice exclusively; such books are of exceedingly small value to the college student. Others are all theory; and these also have small value for the purposes of the teacher. The first may be written by college graduates but certainly not by college professors. Some text-books give theory in the first half, and then practice, with very little connection between the two, which is undesirable. At least one correspondence school combines theory and practice quite neatly for the purposes of its work.

A great majority of our text-books have drawings and illustrations which are referred to by numbers in the books, but which have no names and descriptions under the figures themselves. That, though on the face a small matter, is a great lack. Another point in the mechanical get-up of the text-book is the question

of paragraphs and paragraph headings. Some writers use few paragraphs and do not use any paragraph designations. For the student to get a logical grasp of such a book, or for the professor to teach him in a satisfactory manner from a book lacking suitable subdivisions and cross-references, is exceedingly difficult. In almost any subject the different parts of a book can be divided up into such headed subdivisions as will form, to a large extent, a complete outline in themselves; and at the same time each can be logically connected with the parts which are previous and those which follow. Some think the correspondence schools go too far in their use of italics, in paragraphing, subdividing, etc., and that the text-books, therefore, become mere tabulations; certainly over-emphasis must also be admitted to be a serious fault.

I do not agree with the author of the paper that twenty or thirty or forty men are desirable in the writing of a text-book. It seems to me that what we want is the individuality of a strong mind stamped upon a text-book; for I believe such an individuality is apt to do as much toward giving a young man the true inspiration of education as does the actual acquirement of facts.

ABSOLUTE AND GRAVITATIONAL SYSTEMS OF UNITS.

BY EDWARD R. MAURER.

Professor of Mechanics, University of Wisconsin.

Since some phases of my subject have been fully and even warmly discussed in previous meetings of this Society, the question arises, "Is it advisable to re-open the discussion?" My own answer is "no" if it be done in a partisan spirit, and "yes" if with conciliatory intentions.

An examination of our records relating to my subject reveals many differences of opinion and view. Apparently every possible position in the disputes has its champion. Under such circumstances, one can not expect to do much immediate harmonizing, yet it may be profitable to briefly review the essential facts in each case and point out in the light of those facts the concessions which ought to be made to secure harmony in usage.

The merits of absolute and gravitational systems of units are generally fully recognized, but a few physicists and engineers have expressed strong disapproval of gravitational and absolute units respectively.

The physicist's only real objection is that gravitation units vary in magnitude with change of locality. He admits of course that the variation is negligible for nearly all engineering purposes; he ought to admit also that for many physical purposes, the variation is of no consequence. I recently asked a physical chemist,

“ How do you express the intensity of a gas pressure? ”

“ So many millimeters of mercury,” he replied.

“ And how do you convert this expression to pressure on the square centimeter? ”

“ I multiply the height of the column in centimeters by the specific gravity of mercury; then I have the intensity of pressure in grams per square centimeter.”

I remarked at once that he had expressed the intensity in a gravitational unit and asked why he, as a physical chemist, did not prefer the proper c.g.s. unit. As expected, he replied that, in this instance, the gravitational unit is the more convenient one, and the accuracy of the measurement does not require any notice of the variation in gravity or use of absolute units.

To take a “ straw vote ” of the physicists on this question, I consulted ten standard text-books on physics. In eight I found more or less use of the gravitational system.

The reasons for the opposition of some engineers to absolute systems of units are not apparent. Their recommendation that only gravitational systems be used in engineering education is not practicable to say the least; the c.g.s. system is already too firmly established and widely used in engineering colleges. Thus all engineering students are taught physics and hence the c.g.s. system; electrical engineering students use c.g.s. and other absolute units in *most* of their professional studies; and in most colleges some of these same studies are pursued by mechanical and civil engineering students also.

In view of the facts just stated, and especially be-

cause all engineering students are now, and will continue to be, taught both systems of units, the minority physicists and engineers should at least cease to *decry* the systems which they do not approve.

“ Mass vs. weight ” is an issue related to my subject and demands some notice. Every fair-minded man will concede, I think, that here the arguments are by no means all on one side. The following are the essential facts bearing on the question:

1. In popular language weight has at least three meanings, two of which are the earth's attraction for, and the quantity of matter in a body.

2. “ Standards of weight ” were established, primarily, to measure quantities of matter in trade, and in so far as the acts of establishment determine the meaning of the word, weight means quantity of matter.

3. Physicists, desiring to distinguish clearly between the earth's attraction for and the quantity of matter in a body, denote these by different words, almost universally by weight and mass respectively.

4. Engineer writers, with a few notable exceptions, have adopted the usage of physicists. The exceptional writers use weight in the popular way, *i. e.*, in a double sense.

This is the way that the situation appears to me: It is unreasonable to expect workers in pure and applied science to observe popular usages if they involve ambiguity, as in the case of weight. It is unfortunate that physicists have chosen to define weight as they have (thus ignoring the law as it were), but the misfortune is not so serious as to call for attempts to convert the physicists or amend the statutes. Finally,

the minority engineer writers should withdraw their opposition, thus hastening the day when we may tell our students that in popular language weight is used to connote both gravity and quantity of matter in a body, but in science, pure and applied, only gravity.

Another disagreement is on the relation of the units of force and mass in gravitational systems. The relation may be taken in an infinite number of ways, but fortunately only two have been chosen. These are:

1. The unit force gives unit mass, unit acceleration, as in the c.g.s. system.
2. The unit force is the earth's attraction on the unit mass.

Adoption of the first relation makes dynamical equations for gravitational and absolute units the same. Thus, always $F = Ma$, $Ft = Mv$, $Fs = \frac{1}{2}Mv^2$, etc. But use of the second necessitates two sets of dynamical equations, the foregoing set for absolute, and

$$F = \frac{1}{g}Ma, \quad Ft = \frac{1}{g}Mv, \quad Fs = \frac{1}{2}\frac{1}{g}Mv^2$$

for gravitational units.

The use of the first relation involves the adoption of uncommon units of mass, while that of the second does not. Thus with the first the unit mass in the so-called "engineer system" is one of about 32.2 pounds, but with the second the unit is the pound itself. In my opinion the uniformity in the dynamical equations gained with the first relation decidedly out-weighs the objectionable necessity of uncommon units.

I wish to explain here, parenthetically, two devices that I have used successfully to familiarize the uncom-

mon unit of mass in the engineer system to my students. I use a special name for the so-called "engineer unit," "*geepound*" (chosen for its suggestiveness), and during the entire course in dynamics I keep upon my class-room table two blocks of cast iron, one weighing one pound, and the other approximately 32.2 pounds. The first is marked "one pound" and the second "one geepound" "32.2 pounds," and "engineer unit of mass." Frequent sight of these blocks fixes the relation between these common and the uncommon units, and students soon learn to reduce pounds to geepounds with as much certainty as they reduce feet to miles.

To ascertain the preferences of engineer authors in this matter, I examined twenty text-books on mechanics prepared for engineering students. I found that four authors use the pound and sixteen the geepound as unit mass. I believe that further inquiry would show that even a larger proportion of engineers use the geepound and hence the poundists to be a small minority. To attain uniformity then it is they who must make the concession.

Another question in dispute, intimately related to the foregoing is this: "Shall we teach that $M = W/g$ and $W = Mg$? Most objectors to these equations belong to the physicist camp, but also some engineer writers eschew them.

The equations may or may not be true. They are true with any system in which unit force gives unit mass unit acceleration, as in the c.g.s., and in that engineer system in which the pound and the geepound are units of force and mass respectively. They are

not true in gravitation systems wherein the weight of the unit mass is taken as the unit force; in those $W = M$.

At least one-half the physicists and nearly all the engineer authors referred to use $W = Mg$ and $M = W/g$ respectively, or, more particularly, W (in dynes) $= M$ (in grams) $\times 981$ c.m. per sec. per sec., and M (in geepounds) $= W$ (in pounds)/32.2 ft. per sec. per sec. I wish to note that weight in dynes and mass in geepounds may be computed by another method fundamentally different; thus,

$$W \text{ (in dynes)} = W \text{ (in grams)} \times 981.$$

$$M \text{ (in geepounds)} = M \text{ (in pounds)}/32.2.$$

This is merely conversion of a quantity from one unit to another of the same kind—a familiar process. Though preferring this method, I do not feel justified to object to the first.

Writers are not agreed on the definition of gravitation units of force. Thus, for example, some take the pound force at any place, as equal to the weight of the pound mass at that place; the magnitude of that unit then depends on locality, or is local. Other writers take the pound force at any place as equal to the weight of the pound mass at London or at sea level, latitude 45 degrees, apparently making the unit an absolute one.

It is true that use of the variable pound force and the corresponding engineer-unit of mass, leads to the apparently awkward fact that the numerical value of the weight of a body does not change with change of place, but that that of its mass does. This fact need not confuse if it be remembered that the numerical value of a quantity depends upon the magnitude of the unit used.

Analogously to the case in hand, if the length of a steel rod is measured at different temperatures by a standard of the same material, the numerical results arrived at are the same (although the length has actually changed with the temperature), and if the length of an ideal rod whose coefficient of linear expansion is zero be measured with the steel standard, the numerical values arrived at will be different, although the length has *not* changed.

In seventeen of the twenty text-books on mechanics before mentioned, I found that the local pound force is used. Moreover, practically all engineers use that same unit. In view of the foregoing and because we already have a well established absolute unit of force, I think that the absolute pound force is superfluous.

There is some difference of opinion as to which units should be taken as fundamental in gravitational systems. Comparatively few writers have expressed themselves on this point. Some take the units of length, mass and time as fundamental, others those of length, force and time. It seems to me that the definitions of the terms "fundamental" and "derived units" govern; hence, for example, in an engineer's gravitational system, if the pound is taken as unit mass, then the unit force is a derived unit, but if the geepound is taken as the unit mass then the unit force is fundamental.

To recapitulate, I have expressed my own position on the questions discussed as follows:

1. There are fields for the use of both the absolute and gravitational systems of units; neither should be taught exclusively in mechanics.

2. In technical literature weight and mass should be used to connote the earth's apparent attraction for and the amount of matter in bodies.

3. It is advantageous to adopt the relation "unit force gives unit mass unit acceleration" in gravitational as well as in absolute systems. (The special mass unit in the engineer's system demanded by (3) deserves a name.)

4. Gravitational units should not be defined so as to be absolute.

5. Units of length, force and time should be taken as fundamental in gravitational systems.

DISCUSSION.

PROFESSOR A. N. TALBOT: It will be agreed that it is important to give the student a fair conception of mass and force and an understanding of the units to be used. For my own part while I have used to some extent the gravitation system I prefer to consider, at least nominally, that both classes of units used are absolute systems. I illustrate the characteristics of the two sets of units by the beam balance and the spring balance. In the so-called scientific system weight means mass, and this is typified by the beam balance, since masses are compared through their property of weight. In the engineer's system, force is the quantity first considered, and here the spring balance carries with it the conception of force as a pull and also the constancy of mass since weight and g vary with the location on the earth's surface. By this treatment both systems of units are absolute systems, and my feeling is that such a treatment gives best results.

I wish to give my appreciation of the geepound.

The difficulty has been that there has not been an accepted name for this unit. If a name had been coined for it as names for electrical units were a part of the difficulty found by students would have been removed.

PROFESSOR C. M. WOODWARD: My students, as far as possible, separate the idea of mass from that of weight, which is a force. I always introduce the spring balance to give an idea of force and its measure. It measures force eliminated from all thought of matter. Pounds never mean anything but force. There is no inconsistency in the two systems. One assumes certain elements as fundamental and the other is derived. One is as rational as the other. Professor Kent once said that certain students never quite knew whether to divide by “ g ” or not. It seems to me that is a most deplorable condition. Those students could not have been taught the fundamentals correctly. I never like to have students tell me that “ g ” means “force of gravity.”

PROFESSOR JACOBY: When students are in doubt as to the units in which each member of a numerical equation is to be expressed it is found to be a good plan to let him write down the units for the separate terms and to reduce the expression to its simplest form. Thus, in the simple equation for flexure, $M = SI/c$ in which M is the bending moment, S the unit stress in the outer fiber at a distance of c from the neutral surface, and I the moment of inertia of the cross-section of the beam, the question arises whether M should be expressed in pound-feet or in pound-inches. If S be given in pounds per square inch, I in inches raised to

the fourth power, and c in inches, the result may be stated as follows:

$$\frac{\text{lbs.}}{\text{in}^2} \times \frac{\text{in}^4}{\text{in.}} = \text{lb.-ins.}$$

whence M should also be reduced to pound-inches.

The reference by the author of the paper to the use of the beam and spring balances leads me to inquire what device has been found most useful to help the student to a clear conception of acceleration, or feet per second per second?

PROFESSOR GROAT: I have avoided the terms "feet per second per second" and feet per square second for beginning students, because that is a little technical; "feet in one second" is more satisfactory: "feet per second in one second" is the way I would put it to beginners.

PROFESSOR MAGRUDER: In answer to Professor Jacoby's question, I would suggest the practical illustration of the tractive force required to take a railroad train out of a station.

I must ask to be allowed to differ from my friend, Professor Gray, in his statement that the gravitational unit of weight or force is immaterial in questions involving statics. In measuring the pressure of a gas or fluid we frequently use the mercury column, and state that the pressure is so many "inches of mercury." This means very little unless the altitude and latitude and the barometric pressure are known. One reason why the results of tests of gas-engines as made in this country do not compare favorably with similar tests made in Germany is that the latter reduce their results to a standard, while we frequently do not. As the

result of this, when contracts are made according to which an engine must deliver a brake horse power for the expenditure of a definite number of heat units, it makes considerable difference, both commercially and practically, as to whether the pressure of the gas-fuel used is given in absolute or gravitational units when compared with results obtained elsewhere.

PROFESSOR A. N. TALBOT: The last remark of Professor Woodward is worthy of another word. He stated that the boy who studies physics says " g " is the force of gravity. When that is traced back it is found that the text-book ordinarily says " g is the attraction of gravity on the unit mass." But the boy forgets all about unit mass, and as most of the equations he happens to use in physics deal with unit mass, he gets the idea that g is a force. This is the source of much confusion.

PROFESSOR MAURER: As one device for explaining acceleration I have the student consider the velocity changes in the case of a freely falling body, using that case because he is more or less familiar with it and probably knows the equations $s = 16t^2$ and $v = 32t$. I ask him to make a schedule of the motion, writing in the first column the numbers 0, 1, 2, 3, etc., to denote values of t , and in the next two the corresponding values of s and v . He knows that these columns should be labelled respectively as follows: " t in seconds," " s in feet," and " v in feet per second." Then he is directed to set down in the fourth and fifth columns the velocity increments for successive seconds and minutes respectively. He readily understands that these two columns should be labelled "velocity increments

in feet per second." Observing now that these increments, or velocity changes (32 and 1,920), occur per unit time, he sees that they are values of the acceleration of the falling body and also that the full description of the acceleration requires the naming of the velocity increment *and the unit time per which it occurs*, thus 32 feet per second *per second*, and 1,920 feet per second *per minute*.

I do not wish to be understood as antagonizing the views of anybody on these matters for I know that there are other positions than those taken by myself which are sound. But believing that more uniformity and system in our systems of units would be of advantage to students, I have ventured to present a set of views which unify the systems, and are sound and in line with the trend of good usage.

ON TEACHING CALCULUS TO ENGINEERING STUDENTS.

BY ALFRED M. KENYON,
Professor of Mathematics, Purdue University.

It is proposed in this paper to set forth some of the methods of presentation and the principal topics presented to the engineering students of the sophomore class in Purdue University. This first course in calculus is given in the second semester of the sophomore year, having been preceded in the first semester by analytic geometry, four hours a week being assigned to each subject in the program. At the opening of the junior year the engineering students take up theoretical and applied mechanics, which continues throughout the year and is accompanied by the second course in calculus two hours a week. The mechanics is not administered by the department of mathematics.

The primary object of this course is to ground the student thoroughly in a few elementary and fundamental principles of calculus; the secondary object is to prepare him to apply these principles and to understand the application of similar ones in his work in mechanics.

In order to grasp the fundamental principles of calculus it is necessary first of all to have a clear understanding of the system of real numbers and of the operations which may, and which may not, be performed with these numbers, and of the uniqueness and definiteness of the results of these operations. With such an

understanding there is no necessity for any mystery or even indefiniteness attaching to such terms as limit, infinity, etc.

A new principle is presented to the student through the medium of a well-chosen example from geometry or physics which is worked out always to a definite numerical result; the exposition, proof, and formulation, in one or another order, then follow. The student then works out numerous problems chosen from physics, laboratory or engineering practice, or geometry, to fix and make definite the principle in his own mind and to get a general idea of the kind of problem in which it is likely to have an application. Great stress is laid on geometrical or graphical representation, by the use of rectangular and polar coördinate paper, and other devices, of the numbers occurring in these problems, and upon the interpretation of the successive processes and results from the graph.

A somewhat limited but consistent and convincing experience has led the instructors of the department to regard this method of presentation as very efficient, to attach especial importance to the right choice of problems, and to appreciate the definiteness that results in the mind of the student who works a considerable number of such problems to a numerical result. Such problems always precede those which (on account of the presence of arbitrary constants) lead to formulas; the latter being introduced very sparingly and gradually as the course proceeds.

As to the matter of rigor, it is not regarded a sin (either moral or logical) for a student to use knowledge which he can not prove; it is all wrong to put him under

the impression that he has proved it when he has not; it is indefensible for either the instructor or the text-book to give him "knowledge" which is not true, or to set before him for proofs, plausible statements which do not prove. It is not feasible, and it is not pedagogically wise to give rigorous proofs of all the theorems that are presented in this course; the student is not ready for it, and even if he were, the time and attention required would detract from the main issue and defeat the very objects of the course; but what is insisted on is that he shall have definite ideas of what is presented to him and shall know exactly what has been proved and what he has accepted on authority and what at some time in an advanced course in the theory of functions of a real variable he must prove in order to put his knowledge of calculus on a strictly logical basis. This is important in the first place because it is nothing more than common honesty on the part of the instructor and the text-book and in the second place because it puts the student in position to do further work in the subject without discovering that his foundations can not be depended up. The discovery that a general theorem, which he has learned and proved in calculus, is not always true, and hence under the hypotheses stated is not generally true, has often wrought confusion in the mind of a student by raising the insidious but pertinent question whether any of the proofs he has been given hold good, has thrown the calculus under suspicion and has led him to abandon it as an instrument to be applied in engineering work. Upon this point I beg to quote from Professor Maximè Bôcher in the *Annals of Mathematics*, vol. 2, page 81: "One of the

most striking tendencies of modern algebraic and analytic work [is] the tendency not to be satisfied with results which are merely true 'in general,' *i. e.*, with more or less numerous exceptions but to strive for theorems which are always true. The great importance of this tendency will be apparent if we remember that when we apply a theorem it is usually to a special case. If we know merely that the theorem is true 'in general' we must first consider whether the case to which we wish to apply it is not one of the exceptional cases where the theorem fails."

The main topics of this course are:

1. The real number system.
2. Functions of a single real variable.
3. Continuity, including a list of the more common continuous functions met with in calculus.
4. Derivatives and derived functions; primitive functions. Here some attention is given to plotting the primitive and derived functions on the same axes.
5. Applications to problems in physics and geometry, such as rates, maxima and minima, tangents, normals, and intersections of plane curves.
6. Some important elementary theorems on continuous functions, including Rolle's and the mean value theorems, as an introduction to
7. The definite integral defined as the limit of a sum. The proof of the fundamental theorem for a continuous integrand. The simpler cases of improper definite integrals (these occur constantly in problems in elementary text-books without so much as mention). The theorems for integration by parts and by substitution illustrated by graphical methods.

8. Finding primitive functions but always for use in a particular definite integral which is to be carried through to a definite numerical result. It is at this point that one of the greatest gains has been made. All integrals are definite integrals to the student; the main object is not lost sight of, and guides in the selection of forms to be investigated; time is saved and efficiency and definiteness are developed.

9. Applications of definite integrals to numerous problems in geometry and physics.

It will be noted the many topics often given in an elementary course are absent from this list. Those which the engineer will have use for are to be given in the second course. The two courses together can not be exhaustive and so the matter of selection becomes important. While varying conditions at different institutions may prescribe a different selection of topics, it is hoped that the discussion will bring out the weakness of this one and show how it can be improved.

ON TEACHING CALCULUS TO ENGINEERING STUDENTS.

BY BENJAMIN F. GROAT,
Assistant Professor of Mechanics, University of Minnesota.

I would rather discuss “ mathematics for engineers ” than “ calculus for engineers ” because I favor a speedy introduction to all the important elementary principles of mathematics followed up by much recurrence and subsequent development.

This method seems to me to be adaptable to all the mathematics necessary to engineers and also to preparatory courses for all students. In such a course as this the calculus, as all other mathematical subjects, would be ever-present and all the principles would recur in increasingly complicated relations.

It should not be said that algebra is the trunk of this mathematical tree but that it is the solvent for all engineering mathematical subjects. The calculus would begin in elementary algebra where it would appear upon a strictly algebraic foundation—later the rules and formulas of differentiation and integration, that is the calculus proper, would take the place of algebraic operations and the advantages of this calculus in analysis clearly set forth.

The algebraic foundation for the calculus is the formula

$$Lt = \frac{f(x+h) - f(x)}{h}, \quad h = 0,$$

originally employed by Fermat in maxima and minima, and the summation formula

$$\sum_a^b [\varphi(x+h) - \varphi(x)] = \varphi(b+h) - \varphi(a).$$

These formulas should be thoroughly treated both graphically and analytically at an early stage.

It is right here that the engineering student gets his best hold upon the notions of limits, summation, limits of sums, differentiation and integration. These are the fundamental ideas which subsequently enable him to quickly discover the integral in a problem in mechanics or physics; and it can not be denied that ability to discover the integral is of more importance to the engineer than ability to perform the integration. This too is the point where approximate integration should be taken up, including Simpson's, Newton's and the related prismoidal formulas and also mechanical methods. Engineering students should be made acquainted with mechanical arithmetic and the various instruments appurtenant thereto from the beginning. Engineering schools must be fully equipped for this purpose.

The text-books and formulations for this course in "mathematics for engineers" should be the joint product of the several classes of professional and scientific men—text-books and formulations which would be satisfactory to all these men. It seems to me to be one of the most important functions of teacher or text-book to show how and where all things interlock.

After having applied the rules of the calculus formally, approximately and mechanically, the higher theory should proceed, subject to the system herein advocated, about as at present. I feel, however, that too much effort is required to make permanent the en-

gineering student's familiarity with elaborate analytic processes for arriving at exact solutions of purely mathematical conditions.

We hear a great deal about the "laboratory method" in mathematics. I do not believe this is the correct name. Mathematics is not a laboratory subject, though it should be applied in the laboratory constantly, and always with a view to obtaining a result—verily applied mathematics. There is surely a tendency among some to overestimate the value of applications in throwing light upon the principles of pure mathematics. No good can come from the use of make-shift instruments of crude construction, either for illustrating mathematical formulas or for teaching the principles of an engineering subject. Instruments of precision were invented for the purpose of making accurate our knowledge of values. They are generally more or less complicated, involve corresponding difficulties of manipulation and require skill on the part of the manipulator—and this skill can not be acquired by familiarity with anything short of the real thing itself. The proper place for the study of such instruments is in the particular branch where they are employed in their true functions. There is no objection to studying the real instruments at any time, but there is objection to crediting time so spent to any other subject.

I am in favor of *coöperative* systematic effort to increase the effectiveness of engineering courses generally.

DISCUSSION.

PROFESSOR WALDO: The reason, he said, that these two papers were placed upon the program at this time

was to enter a protest against the drift of some of the assertions and beliefs voiced at the Niagara joint meeting of the American Institute of Electrical Engineers and this Society. The careful reader of papers presented by leading practicing electrical engineers at that time is certainly forced to the conclusion that, in the opinion of the essayists, the study of the calculus has little influence on the career of an engineer. Teachers of the theories which lie at the basis of scientific engineering know that the opposite is true—or, at least, that it ought to be true. The opposite must be true if the student understands his calculus. The difficulty is that the inner meaning of the calculus has so often been entirely concealed under a mass of symbols. With these the student has simply juggled and at the conclusion of a course in the subject he usually finds it impossible to make any practical use of his new tool. Such, at least, has been too frequently the case. It is believed that better methods are prevailing and that students in our technical schools, at least, are coming to a clear and lively apprehension of the ways that such subjects as stresses and confined gases may be illuminated by the infinitesimal method. Professor Kenyon has been making a special study of methods of presentation. Some concrete illustrations of his results are to be seen in the Purdue booth but a few steps from the place of meeting and in the same building.

PROFESSOR A. N. TALBOT: The time left for discussion was brief, but he wished to give expression to his appreciation of the fact that the last two papers were placed upon the program. They illustrated the advance that is being made in the rational treatment of

the calculus and especially in its application to the requirements of the engineer.

PROFESSOR JOHNSON: I can not help expressing a regret, which I think must be shared by others present, that some such methods as those just described were not in vogue twenty years ago when we were floundering in the early stages of our calculus experiences.

THE WORK OF THE DEAN OF THE FACULTY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

BY ALFRED E. BURTON,

Dean of Massachusetts Institute of Technology.

The appointment of a Dean of the Massachusetts Institute of Technology was a deliberate attempt on the part of one of the larger technical colleges to introduce a more personal element into the administrative work and general oversight of the studies.

In the smaller colleges it is not difficult to bring about close relations between faculty and students, but in the larger colleges this relation becomes formal and is altogether too apt to be neglected.

This Institute of Technology was founded in 1861. Its growth has been gradual and methods suited to the government of small numbers have been used with the large numbers, any lack of efficiency in these methods being overlooked or endured, until a change of administration brought new minds to bear upon the problems.

There is a tendency in our large universities to assume that high standards can be maintained merely by the rigid enforcement of rules and examinations. We are apt to believe that we are illustrating the principle of the "survival of the fittest," but my two years of experience as Dean of the Massachusetts Institute of Technology has led me to believe that this assumption is not correct and that the result of such administration is too often the survival of the student who most readily

accommodates himself to the machinery of the educational institution and who is most docile and ready to submit to requirements demanding patience and perseverance rather than vigor and activity.

In creating the office of Dean of the Massachusetts Institute of Technology it was intended to introduce a means of modifying and adjusting general rules to individual cases. Conditions at the Institute are in certain respects unique. In our American colleges the dean is generally the administrative head of some main division of the larger institution. It was not desired at the Massachusetts Institute of Technology to separate the divisions of instruction in this manner. The administrative work is so distributed among various officers that the dean has a less extended list of functions but deals with a larger number of students than would ordinarily be the case elsewhere. According to faculty rules it is the duty of the dean to "coöperate with the president in matters relating to the general welfare of the students, including discipline; to have a general oversight of first-year work in consultation with heads of departments; to act as general consulting officer for all the students." There was objection raised to the title, but as no more suitable designation for this officer was presented the title was finally adopted.

The first duty of the dean is to coöperate with the president in all matters relating to student discipline. Owing to the location of the Institute, in the center of the city, and the widely scattered residences of the students, matters of discipline form a very small part of the duties of either president or dean. It has not been

found wise or necessary to introduce graded forms of punishment for the infraction of rules of conduct. There is practically but one form of discipline, a requirement to withdraw, quite unqualified by any suggestion of future reinstatement. A student, however, may be warned or put on probation, but when required to leave on account of a low record in his studies, for dishonesty in his work, or for any other reason, notice of the faculty action is sent to him and to his parents or guardians and there is no other publicity. Faculty votes, under the new arrangement, are now occasionally conveyed to the student orally by the dean rather than by formal letter from the secretary. The dean serves somewhat the office of go-between for the students and the faculty. The faculty may ask him to convey their wishes to the student; the student may ask him to present his case to the faculty. It is expected that the dean should be an officer to whom the student may explain by personal conversation matters which he desires to have brought before the faculty. It is not expected that the dean shall act as an advocate for either side, but that he shall furnish an opportunity for a fuller and more personal statement of the situation than might otherwise be obtained.

The second part of the duties of the dean is to have a general oversight of the first year's instruction. The first-year work at the Institute is practically the same for all students, and up to the time of the appointment of the dean had been under the direction of a committee of the faculty. At the end of the first year the students become definitely separated into the different depart-

ments and their work after that is directly under the supervision of the professor in charge of the department. Instruction under this arrangement was somewhat uncoördinated. It seemed to be the business of no one in particular to interfere or to make changes. The student also felt that he was in a sort of preparatory department and was not a real part of the Institute. The main object appeared to be to pass the examination in order to later enter upon his professional work. By the appointment of the dean it was planned to have some one person directly responsible for the methods and results of the teaching in the first year. The plan was to see that there was a proper coördination between the work of the first year and that of the later professional years. The dean was not only to make the instructor interested in this effort but to make the student feel that he had already entered upon his professional work. It was thought desirable that this officer should meet first-year students in lectures at intervals during the year; to give them some talks on engineering subjects, touching on some of the fundamental ideas, and showing the relation of this preparatory work to the future engineering work. At this period of his education the student is quite susceptible to general and, I may even say, to superficial talks on engineering questions, and if such lectures were to do no more than stimulate enthusiasm for the preparatory work and guide in the choice of a future profession they would serve a very desirable end. These first lectures were not intended to be lectures for examination; it was thought that they might be used as means for giving training in note-taking, but their prin-

cial object was to make the student appreciate the importance of preliminary training. It is especially true in mathematics that the student rarely sees in elementary work the application of what he is studying. There are plenty of opportunities for professors teaching more advanced subjects to show the relation of first-year mathematical to future engineering work. When a student grasps this definite connection between his present mathematical work and his future constructive work he at once takes a new interest. The success or lack of success of such lectures as I have mentioned must depend to a great extent upon the personality of the lecturer, and it might be better in the arrangement of such courses to employ different men to take up different subjects rather than to have the course conducted by one only.

Another portion of the work of the dean is to be the general consulting officer for all the students. It is this work that is supposed to take the greater portion of his time. It was not known before trial whether there was great need of such a consulting officer, but during the first year the office was open there were eight times as many students who came voluntarily for advice as were sent by instructors or other officers. The number of such men who consulted the dean voluntarily the first year was four hundred and fifty. Since that time there has been no record kept of the number presenting themselves, but it is fair to say that there has been an increase. The students do not use this officer merely to save time and gain information which could be obtained in other ways, but often the questions asked are of vital

importance. The man undertaking to answer such questions, if he is at all conscientious, must often tremble at his responsibility. The student of the average age of those entering the Institute of Technology, eighteen or nineteen years, is at a peculiarly critical period of development both as to character and as to habits of life. It is the latter portion of the adolescent period. A student likes to think of himself as a man, while he knows that he is a boy. He is occasionally filled with courage and confidence and again with distrust. He wishes to break away from older influence, from home surroundings and parental advice, and to start out for himself. He is more ready to take advice and suggestions from those outside his home than he will ever be again, and in some one of these moods he comes to the dean, of whom he may have heard as a just adviser, in quite the same manner that he goes to a physician when he wishes advice about his health. The students themselves would hardly care to acknowledge the fact that they often need this sort of advice, but the fact is that they come, and that in some cases their coming is of value to them. The very act of talking over their troubles is of value to them. In the smaller colleges it is the president who does this work for the students. In larger colleges the duties of the president will not admit of this sacrifice of time to individuals. It is there that it is found necessary to designate one man who shall make it his most important duty to try to get into personal touch with the students. Such an officer, however, should have at the same time a connection with the school as a teacher. It would

not be desirable to have as consulting officer one whose only function in the school is the giving of advice. He should gain the respect and confidence of the students, partly at least, from the instruction given in some branch of study in which they are interested. This officer should make every effort to appear to the students as one easy of approach, and this necessarily implies that he should be ready to accept all kinds of social and informal invitations from them, matters that in his capacity as professor he does not deem of much importance. The student is extremely sensitive to the slightest change of attitude in the one to whom he is going for advice. A man must be of even temper, and indeed such a being as it is difficult to find, especially in the engineering world. It may be easier to find such a man in the field of the ministry, but unfortunately for our students the minister doesn't seem to be the one fitted for these particular men. They do not respect the opinions of ministers on professional subjects.

At the Massachusetts Institute of Technology this whole matter is somewhat of an experiment and the question of the real worth of this kind of introduction of the personal element into the machinery of the university is one that is not yet settled. I bring this subject to your attention as a matter for discussion rather than a matter for commendation.

DISCUSSION.

THE PRESIDENT: The point of view can, perhaps, be illustrated in a way by my stating that at a very large gathering of the alumni at which Professor Burton spoke, he was introduced by the presiding officer as "the

friend of the boys.' It requires for that work a man of peculiar temperament. It requires a man who is a good judge of character, who has a very kindly temperament, but who can not be imposed on. And we think we have selected that kind of a man.

PROFESSOR WOODWARD: Is this officer, the dean, selected by the president or by the faculty?

PROFESSOR BURTON: The dean is elected by the faculty. His nomination in this particular case came from the president. It is probable that the faculty would not have taken the initiative in this appointment. The nomination came from the president, who looked at the institute work from the standpoint of an outsider. The election is by faculty rules an annual one, conducted in the same manner as is the election of the secretary of the faculty.

PROFESSOR JACOBY: You say the dean is a go-between to the students and the faculty. I would like to ask whether it is the custom there to permit the students to appear before the faculty to present their own cases under certain circumstances?

PROFESSOR BURTON: In certain cases where the student is being disciplined or sent away for misconduct he is always asked to appear before a committee of the faculty. This committee is usually composed of five or six members appointed by the president. Such a committee does not necessarily include the dean.

PROFESSOR McNAIR: I would like to know something of the relation between the office of the secretary of the faculty and the office of the dean. I know something of your secretary's work at the Massachusetts Institute

of Technology. I would like to know how the two officers are related.

PROFESSOR BURTON: The duties of the secretary have been diminished in extent by the appointment of the dean and the assignment of larger functions to the Registrar and Recorder who are responsible to the secretary. The latter has still his previous general administrative duties, combined with instruction not previously possible. In former years the dean's work must have been shared by both president and secretary, as there were no other administrative officers. The dean's duties are principally to have a general oversight of first-year students, and to become a general consulting officer for all the students. Matters of immediate faculty business, questions in regard to admission to different courses of study, or admission to the Institute, are still part of the secretary's work as formerly. It was not intended that the dean should relieve the secretary of any considerable part of his duties.

PROFESSOR McNAIR: That point is partly what I wished to bring out. It seems to me that more or less of this work must have been done formerly by the secretary, and the idea is simply to make larger opportunities for the student to get advice from some older person upon whom he can depend. Now one more question. I would like to know if you can state the percentage of students who have consulted the dean in this way in the past year?

PROFESSOR BURTON: I kept the number of students the first year but have not done so the second.

PROFESSOR McNAIR: Was the list larger the second year than the first?

PROFESSOR BURTON: Yes. The number for the first year was four hundred and fifty, the great majority of student callers being from the entering class.

I would like also to say that the secretary's work, which was becoming more than could have been carried successfully by any other man than Dr. Tyler, so increased in amount as to require the appointment of a Registrar and a Recorder. The work of the dean has been carried on with the help and coöperation of Dr. Tyler. It would have been impossible to have made the dean's work in any sense successful without such coöperation, and at the end of the first year it was not at all certain that the four officers together had fulfilled their task as satisfactorily and as systematically as did the single officer in the past. I think, however, that there is a gradual improvement taking place.

PROFESSOR MAGRUDER: Do the upper classmen have the privilege of going to the dean as do the others?

PROFESSOR BURTON: It is one of the duties of the dean to be a general consulting officer for all the students, and although the larger number of men who avail themselves of this opportunity are of the first-year class, there are a considerable number from each of the four classes.

There is one duty of the dean of which I have neglected to speak. He is chairman of the Committee of Advisers. Each new student is referred to some member of the instructing corps, preferably one from the department in which the student seems to be most interested. Just before the opening of the school year the new students are invited to meet the Committee of

Advisers informally. Those who present themselves are assigned at once to some one of the instructors, and the instructor gives all possible assistance in explaining the system of registration and the routine work of the Institute. Not more than ten men are assigned to one adviser. A notice of this assignment of the student to an adviser is sent to his parents or guardian. I will say that while this scheme appears to be a good one in theory, it practically does not amount to much. Of course there are exceptional cases, and exceptional advisers, who may be regarded as candidates for future deanship at the institute. In general our instructors are so busy with their regular assignments that they have little time or inclination to interrupt their work for consultation with students. The student finds the man to whom he is assigned so occupied that he hardly dares to interrupt him.

PROFESSOR WILLIAMS: It would seem desirable in all our colleges to have some official, such as the dean or a class officer, who should have special charge of the freshman class. Having been class officer at my own institution for some time past, I have frequently found it advantageous to counsel members of this class in making their arrangements for work, though our course is somewhat rigid in this year. We ought to have a class officer for each class and a dean of the college who is chairman of the general classification committee, composed of all the class officers in the college and academy. Each of these officials is expected to give proper attention to students who are not doing satisfactory work. During the freshman year much may be done to prop-

erly direct or encourage students needing stimulus or advice, and the class officer is better able to present cases to the committee or faculty than can be done by a formal communication through the secretary.

BENJAMIN FRANKLIN LA RUE.

Died December 22, 1903.

Benjamin Franklin La Rue was born November 27, 1857 in Jackson County, Michigan. He graduated from the Jackson High School in 1876. From 1880 to 1883 he was assistant engineer on the Mackinac Division of the Michigan Central Railway. In 1883 he was city engineer of Jackson, after which he was engaged on the Mississippi River Survey by the United States Government. From 1886 to 1894 he was employed as constructing engineer by the King Bridge Company of Cleveland, Ohio, and the Kansas City Bridge Company of Missouri. During the construction of the Eads Bridge at St. Louis Mr. La Rue was stricken by the dreaded caisson disease, which completely paralyzed his lower limbs and from which he died December 22, 1903.

At the time of his death Mr. La Rue was president of the Scranton Engineers' Club, a member of the Society for the Promotion of Engineering Education, principal of the School of Civil Engineering of the International Correspondence Schools, author of several books pertaining to civil engineering subjects, and a frequent contributor to technical journals. Mr. La Rue's cheerfulness and geniality under great physical suffering was but one phase of a character that endeared him to his associates; and made him a source of inspiration to all with whom he worked. He was extremely careful, painstaking and accurate in everything he undertook, realizing in this respect the ideal of an engineer. His sense of humor was keen and he thoroughly enjoyed a joke or a well told story. His death is a distinct loss to the engineering profession and to the International Correspondence Schools, of whose Faculty he had been a member for ten years.

THOMAS MESSINGER DROWN,***Died November 16, 1904.**

Thomas Messenger Drown, born March 19, 1842, was graduated from the Philadelphia Central High School in 1859, and from the medical department of the University of Pennsylvania in 1862. After a brief period of practice as a physician, he turned to chemistry as his life work and studied at Harvard and Yale, as also for three years in Germany, at Freiberg and Heidelberg. In 1873 he was elected secretary of the American Institute of Mining Engineers which position he ably held for eleven years. From 1874 to 1881 he filled the chair of chemistry in Lafayette College. In 1885 he accepted the professorship of chemistry in the Massachusetts Institute of Technology, where he built up a strong department which had, at the time of his resignation, twenty-one instructors and five hundred students. From 1887 to 1895 he was in charge of the chemical department of the Massachusetts State Board of Health and made important researches regarding water supplies, one of the most valuable being that which produced the map showing the normal chlorine in the natural waters of that state. He was elected in 1884 an honorary member of the American Institute of Mining Engineers, in recognition of his services in editing its transactions, and in 1897 he was its president. The degree of Doctor of Laws was conferred upon him by the University of Pennsylvania.

In 1895 Dr. Drown was elected president of Lehigh University which position he filled until the time of his death. Thoroughly familiar with the aims and needs of technical education, and being highly qualified by temperament and experience, his administration was most successful. The curriculum was extended, the teaching force greatly enlarged, and the number of students nearly doubled during the nine years of his presidency. He was an earnest advocate of broad training and of the development of high character in students. While he urged the greatest thoroughness in instruction in technical subjects, he deemed it essential that every student should have a good training in the English language and some knowledge of other cultural subjects. In a paper published

* Memoir prepared by Professor Mansfield Merriman.

in Vol. IV. of these Transactions, his views regarding instruction in modern languages for engineering students are presented.

The death of Dr. Drown came suddenly and was a great shock to his numerous friends, especially to his co-workers in Lehigh University. His genial disposition, his earnestness, his tact, his rare ability to avoid contention, and his broad knowledge rendered his administration as president one of great success. His work in advancing science and in promoting engineering education was one which will long continue to bear good fruit.

ROBERT HENRY THURSTON,*

Died October 25, 1903.

Robert Henry Thurston was born in Providence, R. I., October 25, 1839. He graduated from Brown University in 1859 with the degrees of Ph.B. and C.E. He received the degree of A.M. in 1869 and LL.D. in 1889. His father, Robert Lawton Thurston, was at the head of a large engine works and Dr. Thurston for two years after graduation was engaged with his father in manufacturing.

During the Civil War he was in the engineer corps of the U. S. Navy and served in DuPont's and Dahlgren's fleets throughout the war. While having the rank of second assistant engineer, he was made engineer in charge of the "Chippewa," in 1863, and later was transferred to the "Dictator," as first assistant engineer. He was present at the battle of Port Royal and the siege of Charleston.

His work as an educator began in 1865 when he was detailed for duty in the department of natural and experimental philosophy at the U. S. Naval Academy. Upon the death of the professor of the department, he was placed *ad interim* in charge under Admiral Porter, superintendent of the academy, which position he held until 1870, when he was relieved by the late Admiral Sampson.

In 1870 he was invited by President Morton to take part in the organization of the Stevens Institute of Technology and to occupy the chair of mechanical engineering, which he held until 1885.

In 1884 Dr. Thurston's health was very poor and he spent the year in Europe. On his return he was offered the position of the directorship with full authority for reorganization of Sibley College, Cornell University, which position he held at the time of his death, October 25, 1903. His death was due to heart failure and came suddenly and without warning. He died on the anniversary of his sixty-fourth birthday and on the eve of a birthday dinner to which several intimate friends had been invited.

Dr. Thurston will always be remembered for his great work in extending the field of engineering education and for the various literary works which he has produced. At the time he took charge

* Memoir prepared by Professor Rolla C. Carpenter.

of Sibley College, Cornell University, in 1885 there were 63 students in attendance; at the time of his death in 1903, there were 1,049 students in attendance. Sibley College has had during this entire time a continuous, although an irregular growth, which is shown in the following table.

Dr. Thurston has contributed as much to the engineering literature of the country as any living author and numerous papers are to be found in the proceedings of the various engineering societies and the *Journal of the Franklin Institute*. He has also written an extensive series of engineering books which are well known and are recognized authorities on the subjects treated. The following gives in concise form the list of books which he has written, with the names of their publishers.

"The Materials of Engineering." J. Wiley & Sons. Part I., Non-metallic Materials of Engineering and Metallurgy; Part II., Iron and Steel; Part III., Alloys and Their Constituents.

"The Materials of Construction." J. Wiley & Sons.

"Treatise on Friction and Lost Work in Machinery and Mill Work." J. Wiley & Sons.

"Stationary Steam Engines." J. Wiley & Sons.

"Development of the Philosophy of the Steam Engine." J. Wiley & Sons.

"A Manual of the Steam Engine." J. Wiley & Sons. Part I., History, Structure and Theory; Part II., Design, Construction and Operation.

"A Manual of the Steam Boiler, Design, Construction and Operation." J. Wiley & Sons.

"Steam Boiler Explosions in Theory and in Practice." J. Wiley & Sons.

"A Hand-book of Engine and Boiler Trials and the Use of the Indicator and the Prony Brake." J. Wiley & Sons.

"History of the Steam Engine." D. Appleton & Co.

"Heat as a Form of Energy." Houghton, Mifflin & Co.

"Reflections on the Motive Power of Heat." J. Wiley & Sons.

"Life of Robert Fulton." Dodd, Mead & Co.

"The Animal as a Machine and Prime Mover." J. Wiley & Sons.

TABLE SHOWING NUMBER OF GRADUATES, NUMBER OF INSTRUCTING STAFF AND NUMBER IN ATTENDANCE AT SIBLEY COLLEGE FROM 1885 TO 1904.

	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904
Resident graduates.....	0	7	9	13	14	14	15	19	28	56	35	22	38	27	27	46	62	76	80*	93
All other grades.....	63	105	177	223	289	374	435	503	553	582	501	501	456	444	455	520	608	722	886	956*
Total	63	112	186	236	303	388	450	522	581	638	536	523	491	471	553	566	670	798	966	1049
No. given diplomas.....	5	10	19	22	32	54	62	90	83	81	87	109	170	90	96	106	120	114	174	.....
No. of professors.....	2	2	3	2	2	2	2	2	2	2	2	5	5	6	6	6	6	7	7	7
No. of associate profs....	0	0	1	1	1	1	2	3	4	4	4	2	1	0	0	0	0	0	0	0
No. of assistant profs....	1	0	1	3	2	3	4	3	3	3	3	2	3	3	3	3	4	5	6	7
No. of instructors.....	4	4	3	3	5	7	5	8	10	11	11	11	11	12	12	12	12	12	13	15
No. of assistants.....	0	2	3	5	6	5	5	6	10	11	12	12	12	12	12	13	12	11	10	17
Total giving instruction	7	9	11	14	17	18	18	22	29	31	32	32	32	33	33	34	34	36	38	41

* Estimated.

BURTON S. LANPHEAR,***Died October 14, 1904.**

Burton S. Lanphear, of the Electrical Engineering Department of the Iowa State College at Ames, Iowa, died at the home of his parents in Carthage, N. Y., October 14, 1904. Professor Lanphear had been obliged to suspend work for a period of recuperation soon after the opening of the college year, but his early death was unanticipated and came as a shock to his numerous friends.

Professor Lanphear was born September 13, 1871, and entered Cornell University, Ithaca, N. Y., in 1890, where he held a state scholarship. He graduated with the degree of M.E. in 1894, and in the following year returned and took the post-graduate degree of M.M.E. During his senior year he was elected to the honorary Sigma Xi fraternity.

Upon leaving Cornell, Professor Lanphear accepted a position as instructor in physics and electrical engineering at the University of Maine, but was later recalled to his alma mater, where he served for a year as instructor. He then accepted a position as expert engineer with the International Paper Company, Buffalo, N. Y., resigning in 1900 to come to the Iowa State College as assistant professor in electrical engineering.

Professor Lanphear was married in 1899 to Miss Emma Parks, Cornell, '96, and is survived by his wife and one son.

He was a member of the American Institute of Electrical Engineers, the Iowa Engineering Society, the Society for the Promotion of Engineering Education, the American Association for the Advancement of Science, and the International Electrical Congress.

His untimely death prevented the carrying out of many promising plans for his future work, and he is sincerely mourned by a large circle of friends.

* Memoir prepared by Professor Anson Marston.

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